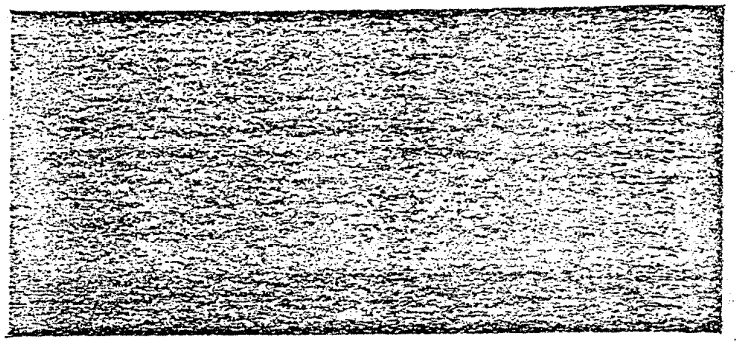
NAVAL SHIPS' TECHNICAL MANUAL



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NAVAL SHIPS' TECHNICAL MANUAL

NAVSEA 0901-LP-635-0000

CHAPTER 635

THERMAL INSULATION

SUPERSEDES CHAPTER 9390 OF JULY 1972

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NAVAL SHIPS'TECHNICAL MANUAL

CHAPTER 635

THERMAL INSULATION

NAVSHIPS 0901-390-0002 (July 1972 Edition), Chapter 9390, Naval Ships' Technical Manual (NSTM) is superseded by Chapter 635 as follows:

1. This revision results from the Naval Sea Systems Command's program to revise, repackage, and reissue the NSTM.

2. All holders of the NSTM shall replace old Chapter 9390 with new Chapter 635.

W. N. Smoot, CDR, USN

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Deputy Commander for Fleet Support

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CHAPTER 635

THERMAL INSULATION

SECTION 1. MACHINERY AND PIPING INSULATION

635-1.1 INTRODUCTION

635-1.2 PURPOSE OF INSULATING. In every power plant there is a heat loss from the surfaces of all hot or warmer objects and a corresponding heat flow to all cold or cooler objects. Insulating materials are applied to impede this heat exchange which may occur in any of three ways: conduction, convection, or radiation.

635-1.3 TERMINOLOGY. Insulation is defined as the material employed to resist heat flow.

635-1.4 Lagging. Lagging is the protective and confining jacket or covering placed over the actual insulating material.

635-1.5 Fastening. Fastening is the miscellaneous item with which insulating material is attached to the surface being covered and with which lagging is fixed to the insulating material.

635-1.6 Coating. A coating is the compound applied to the lagging surface to prevent the passage of fluids, liquids, or gases through the lagging and into the insulation.

635-1.7 Conduction. Conduction is the heat flow from one part of a body to another part of the same body, or from one body to another with which it is in physical contact, without displacement of the particles of the body. This manner of heat flow is most important in insulation as it is the low conduction which results in the greatest temperature differential between a hot insulated surface and the atmosphere (as in steam piping insulation), or the relatively warm atmosphere and a cold surface (as in refrigerating plant insulation). Heat transfer from insulated pipes or large blanketed or cemented surfaces (turbines, evaporators, etc.) to the outer surface of their lagging is included in this mode. Conduction is associated with solids and comparison of materials in this respect is measured by the thermal conductivity or k factor.

635-1.8 Thermal Conductivity. This characteristi of materials, also referred to as the k factor, ex presses the rate of heat conductivity in British ther mal units (Btu) per inch of material thickness pe hour per square foot of area per degree Fahrenhei temperature differential. Representative thermal con ductivity, k, is set forth in table 635-1.

635-1.9 Convection. Convection is the process b which heat is transferred from one point to anothe within a fluid, gas, or liquid, by circulating or mixin of one portion or the fluid with another. These cu rents are produced by warm fluid being displaced b heavier cold fluid. Convection reduces the effectiv ness of air space insulation unless such space is ver small.

635-1.10 Radiation. Radiation is the method heat transfer by which a hot body gives off energ in the form or radiant heat which is emitted in a directions. Radiant heat, like light, travels in straigl lines and with the speed of light. The surface cond tion greatly affects the ability of a body to radia heat. Radiation from surfaces varies from very lo values for aluminum, polished copper, or polishe steel to a relatively high value for a black painte surface. Conversely, bright, shiny, smooth surfac are good heat reflectors.

635-1.11 Surface Emissivity. Surface emissivity (1 is the ability of an opaque material to emit radia energy as a result of its temperature. It is measur by the ratio of the rate of radiant emission of t material to the corresponding emission of a therma black body at the same temperature (1.0). Almo all shipboard materials have high emissivity (0.9 higher); that is, regardless of optical appearance, th are thermally black or very dark grey. Exceptio are highly polished bare metals, which have emissi ties of approximately 0.1, and aluminum pain which have emissivities varying from 0.24 to 0.90. it is necessary to estimate the emissivity of a surfa such as a white-painted pipe covering, an estimate 0.95 is a good guess.

635-1.12 FUNCTION OF THERM. INSULATION. In order to minimize the transfer heat from, or to, a body or surface which is hot or colder, respectively, than the surrounding atm phere, thermal insulation is applied. This thermal sulation is a material or materials having a low th

TABLE 635-1

REPRESENTATIVE THERMAL CONDUCTIVITY

Material	Mean Temp. °F	k
Chrome brick	1652	13.8
Concrete	40	12.0
Copper	32	2190.0
Steel (0.1% carbon)	212	312.0
Rigid ploy urethane foam[1]	50	0.14
Cellular glass[2]	50	0.39
Cork	50	0.32
Calcium silicate	200	0.40
Elastomeric foam[3]	75	0.28
Fibrous glass[4]	75	0.23

[1] 2 lbs/cu ft density
[2] 9 lbs/cu ft density
[3] MIL-P-15280
[4] MIL-I-742

mal conductivity. While increasing the economy of a machinery plant, thermal insulation also reduces the quantity of air necessary for ventilating and cooling requirements and prevents injury of personnel due to burns from contact with hot parts of apparatus. It also ensures more uniform heat distribution within equipment. Another funcition of thermal insulation is to prevent sweating of cold surfaces on which atmospheric moisture condenses, thus causing undesirable dripping as well as accelerated corrosion of the metal. Insulation must be sufficiently effective to reduce heat losses and lower surface temperatures to a degree which will permit habitable conditions in a specific space or compartment.

635-1.13 SAFETY PRECAUTIONS

635-1.14 DUST PRODUCING MATERIALS. Certain mineral dust (especially asbestos) cause pathological changes in the lungs. The damage done is permanent and cumulative with continued exposure. To minimize the hazard caused by airborne particles during the fabrication, installation, repair, and removal of piping and machinery insulation, lagging, and other forms of thermal insulation, precautionary measures must be observed. Thermal and acoustic insulations already installed in ships, whether or not they contain asbestos, should not be removed if they are intact and meet design requirements. Thermal and acoustic insulations containing asbestos become a serious health hazard only when handled during installation or rip-out when dust particles are emitted into asbestos insulations, all safety precautions and procedures as specified herein shall be rigidly observed.

WARNING

Asbestos is recognized as a major health hazard. Inhalation of invisible fibers of this material can lead to serious impairment of health in subsequent years.

635-1.15 Asbestos. Asbestos is recognized as a major health hazard. Exposure occurs by inhalation of asbestos fibers produced as a fine dust when asbestos is handled during fabrication, installation, or removal (rip-out) operations. Inhalation of even small amounts of invisible asbestos fibers can lead to serious health impairment. For this reason, it is the policy of the Naval Sea Systems Command (NAVSEA) that asbestos and materials containing asbestos shall not be used in future construction, overhaul, repair, or maintenance of Navy ships where suitable alternative materials are available. Suitable alternative asbestos-free thermal insulation materials have been identified for almost all ship machinery, boiler, and piping insulation uses and are required by MIL-STD-769 and in other sections of this chapter.

1. For many years, asbestos has been used in high temperature machinery, boilers, and piping insulation. Thus, for many years in the future when this isulation is removed, a health hazard will be present. Since it is difficult to identify asbestos in an insula-

assumption that asbestos is present unless it is suitably marked or identified as non-asbestos.

2. The occupational health and enviromental protection problems associated with asbestos are contained in Appendices A, B, and C. These appendices provide information and requirements with regard to:

a. Permissible exposure concentration
b. Industrial hygiene control measures
c. Personal protective equipment
d. Method of measuring airborne asbestos concentrations
e. Monitoring of airborne asbestos
f. Caution signs and labels
g. Medical examinations
h. Industrial hygiene technical assistance availability

635-1.16 Fibrous Glass (Asbestos Free). Persons exposed to fibrous glass may experience irritation of the skin, eyes, and upper respiratory tract, particularly upon their initial exposure or if their exposures are infrequent. After being exposed to fibrous glass on a regular basis for one or two weeks, most workers will no longer experience these irritant effects. Limited epidemiological studies of long-term workers in the fibrous glass manufacturing industry have not demonstrated significant health effects in the workers which could be related to fibrous glass exposure. Research in this problem area is continuing. Until this issue is resolved it is considered necessary to require the use of protective respirators whenever there is inhalation exposure to fibrous glass.

1. The personnel exposure limit value for airborne uncoated fibrous glass is 10 mg/m^3 for fibers of less than 5-7 micrometers in diameter. Whenever feasible, levels of airborne fibrous glass shall be maintained below the personnel exposure limit value.

2. Respiratory protective devices, such as reusable or single use air purifying repirators, shall be worn whenever the airborne concentration of fibrous glass may exceed the personnel exposure limit or while working with fine or ultrafine glass wool. Respirators shall be required for all rip-out of fibrous glass thermal insulation unless measurements show that the personnel exposure limit is not exceeded. Personnel engaged in fibrous glass sanding or finishing operations which generate large, airborne quantities of fine glass particles shall wear respiratory protection.

3. Safety glasses with side shields, goggles, and face shields (where necessary) shall be worn during rip-out of fibrous glass insulation, when applying fibrous glass material overhead or in any area where there is likelihood that airborne paticles may get in the eyes.

4. Personnel occupationally exposed to fibrous glass shall have access to washing facilities with warm water and soap to assist in removal of glass fibers from the skin.

5. Personnel regularly exposed to fibrous glass shall be provided with clean coveralls daily. Fibrous glass contaminated clothing shall be laundered separately from other clothing.

6. Fibrous glass waste and scrap shall be collected and disposed of in a manner which will not result in its dispersal into the atmosphere.

7. Cleanup of fibrous glass dust shall be performed by vacuum or wet cleaning methods.

8. Compressed air shall not be used for cleaning clothes, machinery, or other surfaces.

9. Where fibrous glass materials are machine sawed, die cut, or slit, local exhaust ventilation shall be used to prevent the escape of dust. A filtered power exhaust hood may be used to achieve this objective.

635-1.17 SHIPBOARD REQUIREMENTS. The following is applicable:

1. Ships in service. The following precaution shall be observed:

a. Removal (rip-out) of insulation (except for flexible foam insulation not lagged with asbestos cloth) and other asbestos containing materials, shall not be done except in an emergency and upon approval of the ships Commanding Officer. Such emergency operations shall only be performed within the limitations of the procedures prescribed in Appendix A.

b. Prior to shipyard overhaul or pier side repair, rip-out shall be deferred until recommendations are received from an Industrial Hygienist.

c. If rip-out must be accomplished while underway or in cases where the services of an Industrial Hygienist are not available, the procedures described herein shall be observed. An air respirator continuous flow or pressure demand (see Appendix A, paragraph 635-A.2.2), shall be worn by all personnel that may reasonably be epected to be exposed to the dust.

2. Tenders, repair ships, and ships having insulation shops. It is recognized that ventilation, handling, and medical surveillance requirements associated with industrial applications can not all be met this time. Where possible, the requirements of Appendix A will be met. Whenever possible, arrangments should be made for monitoring the spaces by a shipyard Safety Officer or Industrial Hygienist to determine asbestos levels and protection required. Airborne limits shall be established as safe by sampling. Where this requirement can not be met, respiratory protection as prescribed in Appendix A shall be provided all personnel engaged in asbestos work

Admittance to shops shall be limited to those personnel having a definite need to be in the area.

635-1.18 SHIPBOARD MATERIALS

635-1.19 INSULATION. Insulating materials for use aboard naval vessels are listed in MIL-STD-769. (They are also listed in the Federal Supply Catalog under Federal Stock Classes (FSC) 5640, 8040, and 9330.)

1. These material and delineated nominal thicknesses are limited to specified temperature ranges and upper limits. When repair work requires material replacement, requirements of MIL-STD-769 will be met.

2. The following characteristics of thermal insulating materials should be met to the maximum extent possible (MIL-STD-769 materials reflect these considerations):

a. Low heat conductivity
b. Noncombustibility
c. Lightweight
d. Capability of easy molding and application
e. Moisture repellent
f. Noncorrosive, insoluble, and chemically inactive
g. Composition, structure, and characteristics unchanged by temperatures at which it is to be used
h. Once installed, should not cluster, become lumpy, disintegrate, or build up in masses from vibration
i. Vermin proof
j. Hygienically safe to handle

3. Insulating materials listed in MIL-STD-769 are available in the following forms in accordance with federal and military specifications (substitutes not conforming to federal and military specifications noted below shall not be used because of potenual fire and other safety hazards):

a. Preformed sectional pipe covering:
(1) Thermal insulation pipe covering, MIL-I-2781
(2) Thermal cellular glass block and pipe covering. HH-I-551 and HH-I-1751/3 respectively
(3) Plastic foam, unicellular, sheet and tubular form, elastomeric, MIL-P-15280
(4) Insulation, pipe, thermal, fibrous glass, MIL-I-22344

NOTE: Molded cork pipe covering formerly was used but is no longer available from domestic sources. Where repair or replacement of this material is required and cork is unavailable, use one of the other materials listed in paragraphs 635-1.36 or 635-1.37 as applicable.

b. Block:
Thermal insulation block, MIL-I-2819
c. Batts, blankets, and felts:
(1) Fibrous glass batt insulation, MIL-I-15475
(2) Mineral wool blanket insulation, MIL-I-2818
(3) Thermal glass fiber insulation felt, MIL-I-16411
(4) Thermal fibrous glass insulation felt (flexible), MIL-I-22023
(5) Plastic foam, unicellular, sheet and tubular form, elastomeric, MIL-P-15280
(6) Insulation blanket, thermal refractory, fiber flexible, MIL-I-23128
(7) Plastic foam, cellular polyurethane, rigid, preformed and foam-in-place, MIL-I-24172
d. Cements:
(1) High temperature insulation cement, MIL-C-2861
(2) Finishing cement, SS-C-160, type III, grade F

4. Thermal insulation pipe covering, MIL-I-2781, is a compounded material usually consisting of molded calcium silicate or diatomaceous earth. It is used in both single and multi layers. It is suitable for temperatures up to 1200°F.

5. Molded cellular glass thermal insulation under specification HH-I-557 is furnished in flat blocks as type I and under specification HH-I-1757/3 is furnished in pipe coverings as type I and in special shapes as type II. The material consists of glass composition which has been foamed or cellulated containing separate hermetically sealed glass cells each a tiny dead air insulating space. It is noncombustible, rot-proof, and acid proof. It is not recommended for vibrating machinery.

6. Elastomeric plastic foam, MIL-P-15280, is a chemically expanded unicellular plastic foam. It is produced in tubular form and split longitudinally when required for ease of application to piping after erection. The cut edges are sealed together with a suitable adhesive cement This low-density material has the advantage of low conductivity and integral vapor barrier. No vapor barrier coating is required. It shall be protected where exposed to high traffic areas. This material is extremely flexible and may be applied to bent pipe and many fittings without special cutting. It is vermin-proof. The plastic has low compressive strength and therefore requires short sections of a more rigid insulation where pipe hangers are clamped over the insulation as on refrigerant piping. This material is used for refrigerant, antis-

weat, and hot pipe insulation in the -20°F to +180°F temperature range.

7. Preformed fibrous glass pipe covering, MIL-I-22344, is made of glass processed from a molten state into fibrous form, impregnated with a binder, and compressed or otherwise formed into pipe covering. This low-density (3.0 to 6.5 lbs. per cu. ft.) material is furnished in 3- to 6-foot lengths to fit all standard pipe and tube sizes. It is fire and vermin proof. This material is used for antisweat and hot pipe insulation in the 28°F. to 370°F. temperature range.

8. Thermal insulation block, MIL-I-2819, is furnished in two classes according to the allowable temperatures for which the materials are suitable. Class 2 of the specification covers insulating material for temperatures up to 1200°F. The maximum density for this class is 14 pounds per cubic foot. Class 3 of MIL-I-2819 is suitable for temperatures up to 1500°F. Its maximum density is 22 pounds per cubic foot. Materials of both classes under MIL-I-2819 must have a minimum compressive strength of 50 psi at not more than 5 percent deformation.

9. Fibrous glass thermal insulation felt, MIL-I-22023, type I, is processed from a molten state into fibrous form and is free from nonfibrous material (shot) bonded with a binder to form flexible felt. This felt is available in five classes ranging in densities from 0.75 to 3.0 lbs/cu. ft. It is suitable for temperatures up to 400°F. The non-fibrous material (shot) content is limited to 1.5% by weight.

10. Thermal glass fiber insulation felt, MIL-I-16411, is available in two types: type I is made of staple glass fibers felted into coverings and woven or bound with wire inserted yarn. It is available in rolls 60 inches wide and 25 feet long for thicknesses of 1, 1-1/2, and 2 inches and in rolls 50 feet long for 3/4-inch thickness. Type II is made of staple glass fibers laminated and felted without use of binders. It is available in rolls 60 inches wide, 75 feet long, for 1/2-inch thicknesses and in 45-foot rolls for 1-inch thicknesses. It is flexible and suitable for all temperatures up to 1200°F.

11. Fibrous glass felt insulation, MIL-I-15475, is composed of glass fibers bonded together to form a semirigid batt. The fibrous glass is pure glass in fibrous form and is inorganic, incombustible, and resistant to salt water and some chemical actions. It cannot mildew, decay, or provide sustenance to insects, rodents, or vermin. The batts are furnished in 3 pounds per cubic foot density. Standard dimensions are 48 or 96 inches long by 24 or 48 inches wide by 1 to 4 inches thick. When this material is used at elevated temperatures, the binding agent burns out at a point between 450°F and 600°F. Hence, batts should be enclosed by sheet steel for support when subjected to temperatures between 450°F and 900°F. The material is suitable for insulating boiler uptakes.

12. Mineral wool blanket insulation, MIL-I-2818, consists of fibers from slag, glass, or argillaceous limestone made by a process of melting, blowing, or drawing, and annealing. The blankets are felted and reinforced by wire netting or metallic lathing on both sides. The material is suitable for use at temperatures up to 900°F.

13. Thermal insulating tape is composed of a woven glass jacket, MIL-C-20079, enclosing a fibrous glass felting or sliver. The jacket may be either in one tubular piece or fabricated of glass cloth sewed into tubular form. The tape is supplied in two forms, one for spiral wrapping and the other for lateral wrapping. That for spiral wrapping is 2 to 2-3/8 inches wide and 1/4 to 3/8 inch thick. The tape for lateral wrapping is 5-1/4 inches wide and 3/8 inch thick. It is suitable for temperatures up to 750°F.

14. Elastomeric foam plastic sheet, MIL-P-15280 type S, may be used on pipe sizes too large for the extruded tubular type and in fabrication of valve and fitting insulation.

15. High temperature insulating cement, MIL-C-2861, is composed of a dry mixture of rock or mineral fibers and clay binders thoroughly mixed to obtain uniform distribution of the ingredients. It is most suitable for insulating large or irregular surfaces. The composition of the cement is such that when properly mixed with fresh water, it can be applied with a trowel or by hand to hot and cold surfaces. One hundred pounds of dry cement will cover 50 square feet of surface to a thickness of 1 inch. After application, it weighs a maximum of 30 pounds per cubic foot. The cement is reclaimable for reuse. The thermal conductivity of this material is 0.70 at 200°F which is higher than nonplastic materials. The cement covered by MIL-C-2861 is suitable for use at temperatures from 100°F to 1800°F service. It is very important that all rock or mineral type cements shall have corrosion-resisting properties conforming to the specification. This cement can be used to fill all cracks when using block or sectional pipe insulation used on fittings or valves, over wire netting to smooth the surface.

16. Finishing and insulating cement, SS-C-160, type III, grade F, is a hydraulic setting cement composed of a dry mixture of modulated rock or mineral wool fibers and a hydraulic binder. One hundred pounds of cement has a covering capacity of 30 square feet to a thickness of one inch. This cement is used as a surface finish over insulating material to provide a hard, smooth finish to which lagging is applied. It also may be used as insulating material for small valves and fittings up to one inch in size. High-temperature insulating cement, MIL-C-2861, or

a mixture of 80-percent MIL-C-2861 and 20-percent Portland cement also may be used to produce a smooth finish over insulation before lagging is applied.

635-1.20 LAGGING MATERIALS. The definition of lagging (paragraph 635-1.4) explains the purpose of this item.

1. Lagging protects the relatively soft insulating material from mechanical abuse to which it is exposed aboard ship as a result of men climbing over piping and the necessary handling of equipment. It supports the insulating material which is subjected to continual vibation. The lagging provides a smooth finish to be painted.

2. The following materials are used in lagging sytems.

a. Cloth:

Fibrous glass cloth, tape and thread (for lagging insulation), MIL-C-20079

b. Paper:

Flameproof and water-repellent sheathing paper, UU-B-790

c. Board:

KAOWOOL M-board or equivalent

d. Cement:

(1) Cement, insulation, high temperature, MIL-C-2861

(2) Hydraulic setting mineral wool insulation finishing cement, SS-C-160 type III, grade F

e. Metallic:

(1) Zinc coated (galvanized), sheet steel, QQ-S-775

(2) Aluminum ASTM A209, 6061

(3) Corrosion-resistant steel (CRES) ASTM A167, AISI 304

3. Fibrous glass cloth, tape, and thread, MIL-C-20079, are manufactured from a good quality of fibrous-glass yarn. The tapes and cloths are made in various weights and weaves. The material may be used for lagging where internal contact temperatures do not exceed 450°F.

4. Sheathing paper shall be type III, grade F, style 10 of UU-B-790. The flameproof and water-repellent paper does not support combustion and absorbs only a small weight of water. The material is used in conjunction with other lagging; see instructions for insulation of antisweat piping. The paper is supplied in rolls 36 or 40 inches wide.

5. Metallic lagging is used as described under paragraphs covering application of insulating materials.

635-1.21 ADHESIVE MATERIALS. Adhesives which comprise one type of fastening as defined in paragraph 635-1.5 are covered by MIL-A-3316 and MIL-A-24179.

1. Adhesive insulation cement, MIL-A-3316, is suitable for securing cloth lagging materials to all insulation except to elastomeric foam plastic per MIL-P-15280. It has properties superior to other adhesives described herein. Cements conforming to the specifications will not adversely affect either insulation or glass cloth.

2. Adhesive cement, MIL-A-24179, is used for securing elastomeric foam plastic insulation to itself and to metals.

635-1.22 COATING MATERIALS. Coating material is defined in paragraph 635-1.6.

1. Coatings are covered by the following military specifications:

a. Fire-resistant vapor-barrier coating, MIL-C-19565, type II (which is only for indoor usage)

b. Coating compound, thermal insulation pipe covering; fire, water, and weather resistant, MIL-C-19565, type I (which is for indoor and outdoor usage)

c. Compound, end sealing, thermal insulation pipe covering; fire, water, and weather resistant, MIL-C-22395

2. Fire-resistant vapor-barrier coating, MIL-C-19565, type II is applied either with a stiff brush or a trowel over the lagging on all porous antisweat and refrigerant piping. It prevents the passage of atmospheric water vapor into the insulation where it will condense and cause the insulating material to become water soaked.

3. Thermal insulating coating compound, MIL-C-19565, and end sealing compound, MIL-C-22395, are used primarily on hot piping insulation exposed to the weather. Their application to the lagging prevents soaking of the insulation by rain or sea water.

635-1.23 REQUIREMENTS FOR THERMAL INSULATION

635-1.24 PREPARATION. All surfaces shall be prepared in accordance with chapter 631 (9190) prior to application of insulation. Cloth and tape lagging should be covered with one coat of fire retardant paint, MIL-E-17970, after installation. The inside covers of removable blanket insulation shall not be painted. Also use metal lagging where necessary to shield insulation from damage by abrasion or impingement of oil spray. Metallic lagging may be painted for appearance in accordance with chapter 631 (9190).

635-1.25 GENERAL REQUIREMENTS. All steam piping, valves, and fittings up to 400°F located in positions exposed to the weather or to salt water

spray should be insulated in accordance with paragraph 635-1.47.

1. Where it is not feasible to apply insulation, paint the piping with two coats of heat and weather resistant paint, TT-P-28, and install suitable guards to protect personnel, and to prevent contact with flammable materials.

2. In general, insulation is required on all machinery, piping, and equipment having external surface temperatures of 125°F. or higher. However, the following equipment should not be insulated:

a. Any hot surface for which freedom from insulation is essential for its proper operation, such as a boiler gage glass

b. Mechanical joints in fuel-oil service piping from fuel-oil heaters to fuel-oil burners (to prevent insulation from becoming oil soaked in the event of leaks)

c. Fuel-oil piping between burner headers and burners

d. Pressure-gage piping

e. Soot-blower valve units and soot-blower flanges

f. Piping in bilges

g. Piping in voids and cofferdams except where omitting insulation, may be detrimental to system operation, such as catapult steam

h. Safety-valve springs and lifting gear

i. Mechanical joints exposed to sub-atmospheric pressures

j. Piping over shower stalls, behind, and under lavatories.

3. Where the detailed instructions which follow hereafter do not specifically include any surface requiring insulation, such surface should be insulated in a manner similar to the requirements for the condition which most nearly approximates that of the surface in question.

4. Tables 635-2, 635-3, and 635-4 indicate various approved insulating, lagging, and fastening materials to be used and minimum thicknesses required for particular services and temperature ranges. Materials with high temperature ratings may be used on lower temperature applications where such usage can be justified by savings in cost, space, or weight.

635-1.26 MAINTENANCE OF THERMAL INSULATION

NOTE: Scheduled maintenance shall be conducted in accordance with the Planned Maintenance Subsystem (PMS) where NAVMAT PMS has been installed.

635-1.27 Once a year at a minimum, and preferably at 6-month intervals, a careful inspection should be made of insulation.

1. All broken or loose insulating or lagging materials should be securely fastened in accordance with instructions herein. If such material is broken, a complete reinstallation may be necessary (see paragraph 635-1.54).

2. In the course of emergency repairs as a result of water damage, insulaton shall be stripped from the piping surface. This procedure will prevent serious corrosion of piping by insulation which carries a large amount of water even subsequent to dewatering operations.

635-1.28 APPLICATION OF THERMAL INSULATION TO PIPE OR TUBING

635-1.29 TEMPERATURES TO 950°F. Thermal insulation pipe covering per MIL-I-2781 which is for services up to 950°F is described in paragraph 635-1.19.4. The thickness of pipe covering should be as given in tables 635-2, 635-3, and 635-4.

1. Single layer molded pipe covering is applied directly on the piping. Side and end joints should be tightly butted. Sections are securely fastened in place with 18-gage (0.049 inch diameter) nickel-copper, brass, or soft iron wire or metal bands. Use three loops or bands per length of insulating material on pipes up to and including 6 inches and four loops or bands on larger pipes. The ends of the wire loops are fastened together to hold the insulating material tightly against the pipe. The wire ends are bent over and carefully pressed into the pipe covering to leave no projection. In double-layer work, both the longitudinal and circumferential joints of the second layer are staggered in relation to the first layer and both layers are secured as previously described. Insulating cement shall be used for pointing up seams and cracks in the insulation on both the inner and outer layers.

2. Thermal insulating tape as described in paragraph 635-1.19.13 is specially suitable for small piping and where space conditions render awkward the use of molded covering. The tape also is suitable for bends. Tape for spiral wrapping should be wired at each 10 inches approximately. Tape for wrapping laterally must be wired at each end of every strip. The lagging should be in accordance with MIL-C-20079. Tape may also be used for temporary repairs when a pad is lost or insulation is damaged (paragraph 635-1.39).

3. Bends. Where bends are encountered in the piping, the sectional insulating material is cut or mitered as shown in figure 635-1 to fit neatly around

TABLE 635-2

INSULATION THICKNESS FOR HOT PIPING
COMPOUND CONFORMING TO MIL-I-2781

Service	Press psi	Temp °F	Pipe Sizes IPS - inches	Recommended Thickness in inches
Main Steam (Superheated)	any	Up to 950	1 1/2 2 - 4 1/2 5 - 7 8 and larger	3 (2) 4 (3 1/2) 4 1/2 (3 1/2 - 4) 5 (4 1/2)
Diesel exhaust	any	850	1 1/2 - 2 1/2 3 - 4 1/2 5 - 7 8 and larger	3 (2 - 3) 3 1/2 (3 1/2) 4 (3 1/2) 4 1/2 (4)
Diesel exhaust	any	750	1 1/2 2 - 2 1/2 3 - 7 8 and larger	2 1/2 (2) 3 (3) 3 1/2 (3 1/2 - 4) 4 (4)
Main Steam (Saturated)	900, 1200	531, 567	1 1/2 2 - 2 1/2 3 - 7 8 and larger	2 1/2 (2) 3 (3) 3 1/2 (3 - 4) 4 (4)
Aux. Steam	400, 600	450, 490	1 1/2 2 - 4 1/2 5 and larger	2 1/2 (2) 3 (3) 3 1/2 (3)
Steam: High Press. Drains	150	365	1 1/2 2 - 2 1/2 3 and larger	1 1/2 (1) 2 (2) 2 1/2 (2 - 3 1/2)
	50	300	ALL	2 1/2 (1 1/2)
Low Press. Drains Aux. Exhaust Evaporators Hot Potable Water Waste Heat Water Fuel Systems		125-300	ALL	1 1/2 (1 - 1 1/2)

NOTES

1. Insulation over 3 inches in thickness is installed in double layers.
2. Thicknesses of insulation in previous issue of MIL-STD-769 (E) is indicated in parenthesis.
3. Insulation thickness has in general been increased over those designated in the previous issue of NSTM and is consistent with MIL-STD-769.

the contour of the bend. Care must be taken to ensure that each segment is securely fastened in place. All openings and crevices are filled with high temperature cement (preferred) or finishing cement, SS-C-160, type III, grade F, troweled smoothly to a uniform surface. Sharp bends may be insulated with insulating felt per paragraph 635-1.19.9 overlaid with 1/2 inch of high temperature insulating cement or finishing cement, SS-C-160, finished off smoothly.

4. Thickness of insulation conforming to MIL-P-15280 and MIL-I-22344 shall be in accordance with table 635-3.

5. Thickness of insulating tape for 1/4 to 3/4 inch size hot piping shall be in accordance with table 635-4. When tape is used for temporary insulation on larger lines. it shall be at least half as thick as insulation required by MIL-I-2781.

6. When damaged pipe insulation is replaced by insulation of greater thickness, the transition circumference will be tapered approximately 2 inches with high temperature cement, MIL-C-2861, before lagging. See figure 635-2.

635-1.30 LAGGING AND SHIELDING. Lagging and shielding should be applied as follows:

1. Rewettable lagging. Glass cloth per MIL-C-20079 is available in classes 4, 6, and 8 permeated with a compatible adhesive. These materials are dipped in water, wrung out, and applied as previously described. Rewettable lagging should not be used in areas where it will be subject to live steam or dampness as the cloth will lose its adhesive qualities.

2. Application of metal lagging. Metal lagging may be 0.014-inch-thick galvanized steel, 0.030-inch-thick type 6061 aluminum, or .014-inch-thick type 304 stainless steel, except for boiler uptakes where 1/32-inch-thick galvanized steel is used. The lagging is rolled or otherwise formed to fit the insulation with allowance for lap joints. Joints should be arranged to prevent flow of water or other liquid through the joint and into the insulating material. The lagging is secured with metal bands or self-tapping screws.

3. Flange spray shields of aluminized glass cloth can be constructed by either method of NAVSEA Drawing No. 2145518. The drawstring method gives a better fit and is easier to install. Flange spray shields are applied to fuel oil and lube oil systems using aluminized glass cloth, MIL-C-20079, class 10.

635-1.31 DIESEL ENGINE EXHAUST FLEXIBLE CONNECTIONS. The purpose of these connections is twofold; to prevent transmission of vibration from the engine to the piping system and the ships structure, and to compensate for thermal expansion of the exhaust piping system. Insulation of the connections must be accomplished in a manner that will not interfere with the performance of these functions. Flexible covers similar to the flexible flange covers described in paragraph 635-1.41 should therefore be used. Filter material of glass fiber felt (MIL-I-16411, type II) or refractory fiber blanket (MIL-I-23128, grade A) will produce a maximum insulating effect with a minimum space requirement (see tables 635-5 and 635-6).

635-1.32 BULKHEAD EXPANSION JOINTS. Continue the insulation under the connection with the pipe covering butting each side of the flange which secures the joint to the piping.

635-1.33 PIPE HANGERS. Where pipe hangers are clamped around the piping, the sectional pipe covering may be stopped at the clamp and the space filled with layers of glass felt per paragraph 635-1.19 to the thickness of the covering. A single layer of glass cloth which extends over the sectional covering 2 inches on either side is wrapped circumferentially over the felt and is secured by wire through rings and hook fasteners to form a take-down seam. Hangers may also be insulated by fitting the molded pipe covering as necessary; use insulating cement to complete the installation.

635-1.34 TEMPERATURES FROM 501°F. TO 750°F. For temperatures between 501°F. and 750°F., thermal insulation pipe covering, MIL-I-2781, may be used. The thickness of pipe covering should be as shown in table 635-2. This material is applied in the manner described in paragraph 635-1.29. Lagging may be in accordance with paragraph 635-1.30.

1. Two feet of pipe immediately upstream of service steam thermostatic steam traps shall be covered with 1/4 inch of insulation cement, SS-C-160, type III, grade F, and covered with lagging cloth. A removable cover made of two thicknesses of cloth shall be installed over the trap.

2. As alternate methods, layers of fibrous glass cloth may be sewn or cemented in place or fibrous glass tape may be applied in accordance with paragraph 635-1.30.

635-1.35 TEMPERATURES FROM 125°F. TO 500°F. For temperatures between 125°F. and 500°F, thermal insulating pipe coverings listed in tables 635-2 through 635-4 may be used subject to the temperature limitations shown in the tables. Lagging may be in accordance with paragraph 635-1.30.

TABLE 635-3

THICKNESS OF INSULATION CONFORMING TO MIL-P-15280[1] AND MIL-I-22344, FOR HOT PIPING

Temperature Range (°F)	Specification	Nominal Thickness (Inch)
125-180	MIL-P-15280 or MIL-I-22344	1/2
181-250	MIL-I-22344	1/2
251-300	MIL-I-22344	3/4
301-370	MIL-I-22344	1

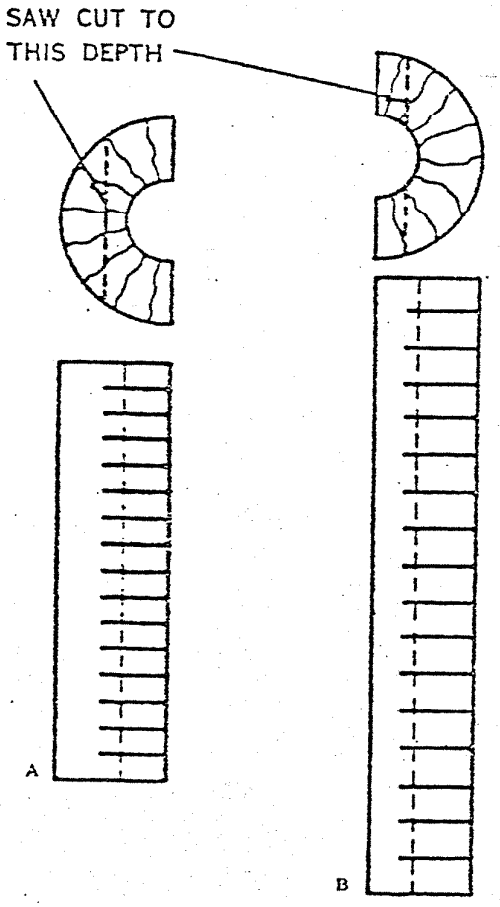
[1] MIL-P-15280 shall be used only for repair where MIL-P-15280 is presently installed.

TABLE 635-4

THICKNESS OF INSULATING TAPE PER MIL-C-20079 AND MIL-I-16411 FOR 1/4 TO 3/4 INCH SIZE HOT PIPING

Temperature Range (°F)	Pipe Size	Nominal Thickness (Inch)
125-250	1/4, 3/8	3/8
251-750	1/4, 3/8	1 1/2 (7/8)
125-250	1/2, 3/4	1/2 (3/4)
251-388	1/2, 3/4	1
389-500	1/2, 3/4	1 1/2
501-750	1/2, 3/4	2

NOTE: Previous thickness per MIL-STD-769E is shown in parenthesis.



A: Detail of inside radius of pipe bends.
B: Detail of outside radius of pipe bends.

Figure 635-1A

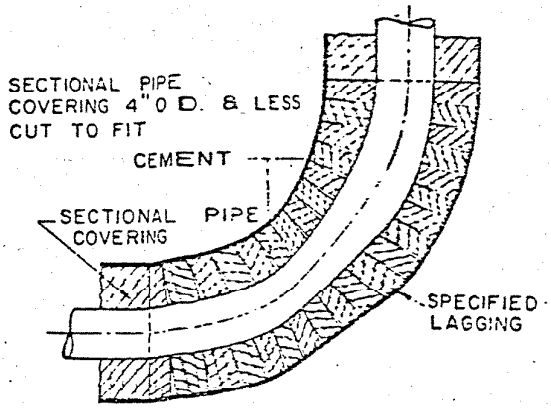


Figure 635-1B

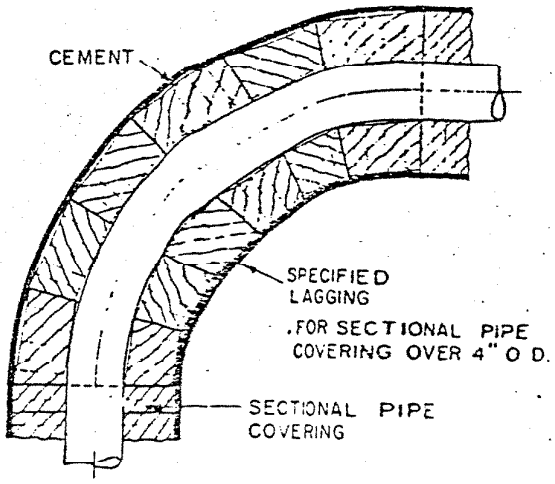
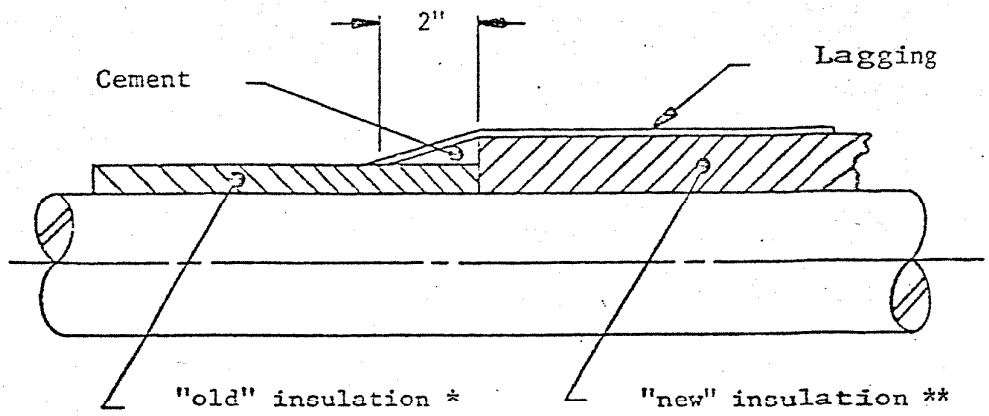


Figure 635-1C

Figure 635-1. Applying Insulation on Contour of Bends in Piping



*thickness specified prior to MIL-STD-769F

**thickness specified by MIL-STD-769F

Figure 635-2. Tapered Transition Circumference

TABLE 635-5

THICKNESS[1] OF INSULATING MATERIALS FOR HOT SURFACES OF MACHINERY AND EQUIPMENT UP TO 850°F

Temperature Range (°F)	Glass Fiber Felt MIL-I-16411, Type II Refractory Fiber Blanket MIL-I-23128 Grade A	Nominal Thickness (Inches)	
		Block MIL-I-2819 Mineral Fiber Blanket MIL-I-2818 Glass Fiber Felt MIL-I-16411 Type I	Insulating Cement MIL-C-2861
125-338	1	1 1/2	2
339-388	1 1/2	2	2 1/2
389-500	2	2 1/2	3 1/2
501-750	3	4	5
751-850	4	5	5 1/2

[1]Does not include finishing cement.

635-1.36 COLD WATER, ANTISWEAT. Piping systems which normally operate at temperatures below compartment temperature may require insulation to prevent condensation of atmospheric water vapor, as well as loss of system efficiency.

1. Such insulation must be coated with vapor-barrier compound to prevent passage of water vapor through the insulation to the pipe surface where it will condense, resulting in water-soaked insulating material and dripping of water on decks, personnel, and equipment.

2. Antisweat insulation should be applied to clean and thoroughly dry piping only. Thickness shall be in accordance with table 635-7.

3. Preformed pipe covering (MIL-I-2781), and

TABLE 635-6

THICKNESS[1] OF INSULATING MATERIALS FOR HOT SURFACES OF MACHINERY AND EQUIPMENT OVER 850°F.

Temperature Range (°F)	Nominal Thickness (Inches)	
	Single Felt Material MIL-I-16411 Type II MIL-I-23128 Grade A	Block MIL-I-2819
851-950	4 1/2	5
951-1050	5	5 1/2
1051-1200	6	6 1/2

[1]Does not include finishing cement.

preformed fibrous glass pipe covering (MIL-I-22344), are secured with number 18 gage minimum (.049-inch diameter) hot-dipped galvanized wire, soft annealed copper wire (QQ-W-343), masking tape or glass thread (MIL-C-20079, type III), spirally wound on 1-inch centers. One layer of water repellent and flameproof sheathing paper (UU-B-790) is wrapped tightly around the insulation and secured with glass thread (MIL-C-20079, type III), masking tape, or 1-inch-wide glass tape (UU-T-106). All joints of the paper are lapped and sealed with adhesive cement (MIL-A-3316, class 1). The compatible lagging is then cemented to the paper using the above adhesive. When the adhesive has dried, the surface is completely covered with vapor-barrier compound (MIL-C-19565, type II).

4. Cellular glass is installed in the same manner as described above, except that the water-repellent paper may be omitted.

5. Elastomeric foamed plastic (MIL-P-15280) is installed without fastenings other than the cement with which the joints are made up. Care must be exercised to assure 100-percent cement bond of the joint since this completes the vapor-barrier which is built in to the material. Lagging shall be in accordance with paragraph 635-1.30 where necessary to protect the insulation from damage.

6. Pipe hangers may be isolated from the pipe by 1/8-inch minimum thickness rubber sheet for antisweat insulation. The insulation is then fitted carefully around the clamp and the hanger rod sealed to the vapor-barrier coating to prevent penetration of the insulation by water in either liquid or vapor form.

7. Anti-sweat insulation need not be installed for:

a. Any cold surface for which freedom of insulation is essential for its proper operation.

b. When only in an emergency condition does fluid flow in the system which could cause sweating such as dry pipe systems, and parts of wet systems such as the piping between sprinkling control valves and their root cut-out valves.

c. Where sweating would not be objectionable, such as in voids and bilges, plumbing fixtures, and the supply and drain piping immediately adjacent to and serving these fixtures.

635-1.37 REFRIGERANT. Cellular glass and elastomeric foamed plastic described in paragraph 635-1.19.3 are used in thicknesses shown in tables 635-8 and 635-9.

1. At the time of installation, the fire-retardant vapor-barrier seal (see paragraph 635-1.22) should be applied to cellular glass in the following manner: The inner surfaces of the semi-cylindrical sections are heavily coated with the compound by brushing and allowed to dry at room temperature for 24 hours. The longitudinal surfaces and ends of each section of the covering are then coated with the compound and the sections are immediately installed, butted together longitudinally, and secured. In the installation of the sections, excess compound which is forced out at the joints may be cleaned off. The lagging is then installed, in accordance with paragraph 635-1.30, and completely covered with vapor-barrier compound, MIL-C-19565, type II.

2. Elastomeric foam plastic, MIL-P-15280 may be applied in 1/4-inch minimum thickness layers as necessary to build up the required thickness. All longitudinal and butt joints shall be staggered. The external surface of sections shall be a continuous skin. All joints shall be sealed with a compatible cement which will assure a continuous vapor barrier. Lagging of elastomeric foamed plastic shall be in accordance with paragraph 635-1.30.

3. Sectional cellular glass covering should be applied with end joints broken by starting with a whole-length piece and a half-length piece and longitudinal joints should be at the top and bottom of the pipe. The sections should be held in place with eighteen gage copper-covered steel wire or 1-inch-wide pressure sensitive tape spaced nine inches apart. When the pipe passes through an insulated wall into a refrigerated room, the pipe covering should extend into the room one inch beyond the wall. Pipe bends are insulated by mitering regular covering to fit the bend, using pieces small enough to get approximately full contact between the pipe and the covering. Foam plastic may be made to fit long-radius bends

TABLE 635-7

THICKNESS OF ANTISWEAT INSULATION (EXCLUSIVE OF VAPOR-BARRIER)

Temperature Range (°F)	Machinery and Equipment		Piping	
	Material Specification	Thickness (inches)	Material Specification	Thickness (inches)
28 to 99	MIL-I 2819, class 2	1 1/2, 3/4*	MIL-I 2781	1, 1/2*
	HH-I-551		HA-I 1851/3	
	MIL-I-27023 type I	1, 1/2*	MIL-P-15280	3/4, 1/2*
	MIL-P-15280	3/4, 1/2*	MIL-I-22344	3/4, 1/2*

*Thickness for application in air conditioned spaces only.

without mitering. Pipe hangers must be on the outside of the covering and must not penetrate the vapor barrier. Frost will form on a hanger rod which penetrates the insulation and eventually will split the cover at the point. Refer to chapter 505 (9480) for pipe hanger and support design.

4. Insulation to prevent freezing. When components conveying fresh water are located where they are exposed to freezing temperature, they should be insulated. Where not exposed to the weather, antisweat type insulation shall be applied; however, where exposed to the weather, the type used for hot piping in exposed weather locations shall be installed (see paragraph 635-1.47). Seawater and other fluids which freeze below 32 °F should not be insulated unless the rate of flow in the system is such that the fluid could freeze and application of insulation would prevent freeze-up during system operation.

635-1.38 APPLICATION OF THERMAL INSULATION TO VALVES, FITTINGS, AND FLANGES

635-1.39 Permanently insulated valves and fittings should be covered to the same total thickness as the adjacent piping. Valves and fittings which are welded into the line are insulated permanently. Flanged valves and flanged fittings may have permanent or removable type insulation. Where the pipe covering is terminated at flanges, provision must be made for removal of the flange bolts or bolt-studs. The pipe insulation may be stopped off squarely and a short removable section of insulating material of sufficient length to permit the withdrawal of the bolting may be inserted.

1. A method considered less desirable is to omit the short removable section of insulation by terminating and beveling off the pipe covering at the necessary distance from the flange.

2. Where permanent insulation is found to be defective or damaged and operations prevent proper repair; a temporary repair can be made by wrapping thermal insulating tape (see paragraph 635-1.29) using table 635-2 as a guide for total thickness required.

3. When removable pad is lost or damaged, the same fibrous glass insulation as above may be used as a temporary repair using tables 635-5 and 6 as guides for thickness with specific reference to MIL-I-16411 glass fiber felt in the tables.

635-1.40 COVERS. Re-usable covers should be fabricated and installed as follows:

1. Fabrication and installation of re-usable covers shall comply with MIL-STD-769.

2. For hot surface applications requiring insulation, re-usable covers shall be installed to permit servicing of machinery, equipment, pipe and valve take-down joints. Re-usable covers shall not be in-

TABLE 635-8.

THICKNESS OF REFRIGERANT INSULATION FOR PIPING EXCLUSIVE OF VAPOR BARRIER

Pipe Size Inches	Temperature Range (°F)	Nominal Thickness (inches)	
		Cellular Glass HH-I-551	Plastic Foam MIL-P-15280
Up to 1 1/4	-20 to -1	2 1/4, 1 1/2*	1 1/2, 1*
	0 to 40	2, 1 1/4*	1, 3/4*
1 1/2 to 2 1/2	-20 to -1	2 1/2, 1 3/4*	1 1/2, 1*
	0 to 40	2 1/4, 1 1/2*	1, 3/4*
3 to 5	-20 to -1	3, 2*	1 1/2, 1*
	0 to 40	2 3/4, 1 3/4*	1, 3/4*

*Thickness for application in air conditioned spaces only.

TABLE 635-9
THICKNESS OF REFRIGERANT INSULATION FOR MACHINERY AND EQUIPMENT (EXCLUSIVE OF VAPOR BARRIER)

Temperature Range (° F)	Thickness (Inches)	
	Cellular Glass HH-I-551	Foam Plastic MIL-P-15280
0 to 35	5, 1 1/2*	3, 1*

*Thickness for application in air conditioned spaces only.

stalled where a vapor barrier is used in conjunction with a thermal insulation.

3. For units of machinery or equipment such as a small auxiliary turbine or for some piping components, where it would be impractical to install both permanent insulation and re-usable covers, the entire insulation may be made re-usable.

4. The valve stem supports on main and auxiliary steam systems from the valve bonnet to within 2 inches of the valve handwheel shall be covered with re-usable covers.

5. Where necessary to prevent impingement of flammable liquids, use only aluminized glass cloth, MIL-C-20079, type I, class 10 for spray shields. (Refer to NAVSEA Standard Plan 803-2145518.)

635-1.41 METHODS OF MAKING COVERS. Readily removable and replaceable covers for piping elements are made by the following methods:

1. Covers may be made in two half sections, using thermal insulating felt enclosed with 0.008 inch diameter knitted wire mesh of type 304 annealed stainless steel on the inside and end surfaces, and with glass cloth conforming to MIL-C-20079 on the outside of the covers. Each half cover shall be sewn and quilted with polytetrafluoroethylene (Teflon) coated fibrous glass yarn conforming to MIL-C-20079 for hand sewing, or coated fibrous glass sewing thread (fully sintered) for machine sewing. The covers may also be fastened with mechanical stapling with stainless steel staples in a manner to provide a uniform thickness, strength and rigidity (See figure 635-3). Where the figure diameter is larger than the outside diameter of the adjacent pipe covering, glass felt shall be used to build-up to the required diameter, figure 635-4. The halves of the covers may be secured by lacing with wire through brass or galvanized steel hooks or rings or snap fasteners. Fasteners attached to cloth lagging must be backed up by washers on both sides of the cloth. Flange covers for below 450°F service may be constructed with glass cloth on both inside and outside surfaces.

2. When a rigid cover is made up of segments of block insulation of the same material used for pipe covering, the block is securely wired to frames of 1/2 inch square mesh of 18 gage (0.049 inch diameter) galvanized steel wire. The wire mesh frames inside and outside of the block insulation have the ends bent over and joints secured with 18-gage, black-annealed, iron wire woven through the

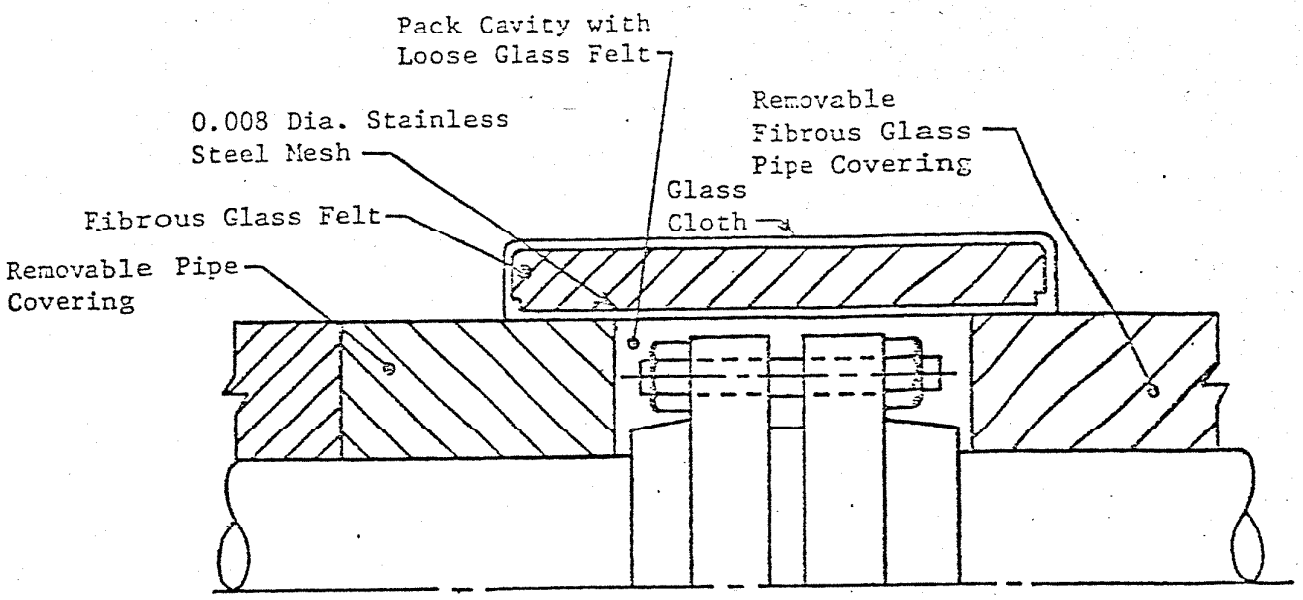


Figure 635-3. Removable Pipe Covering Stapled for Uniform Thickness

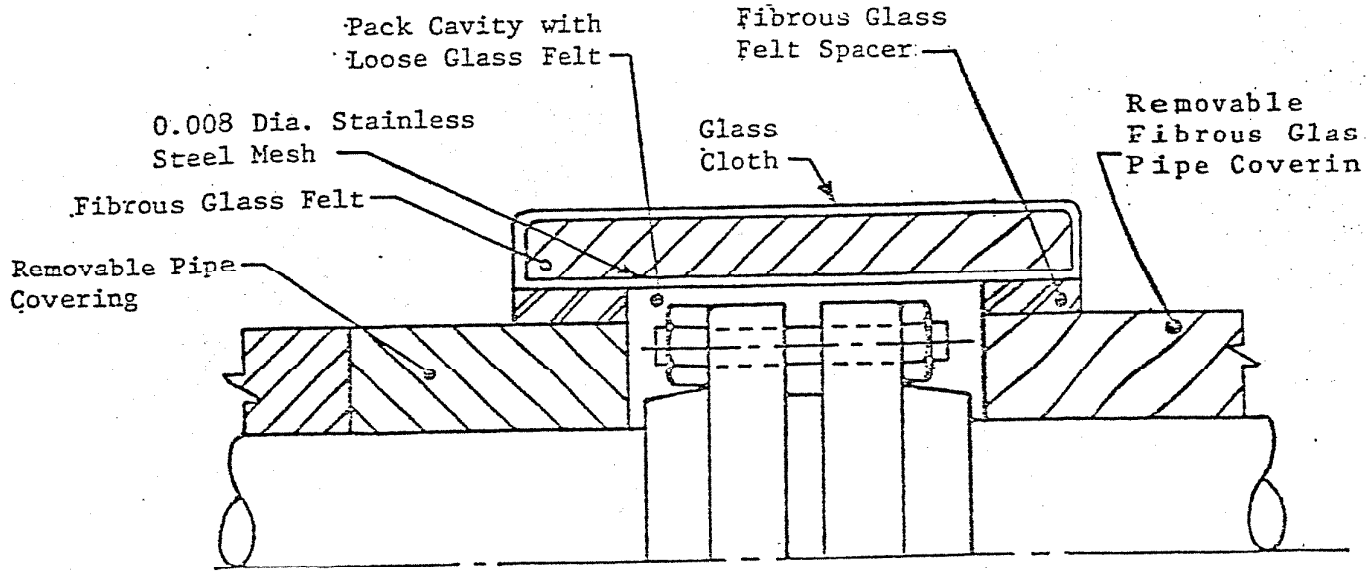


Figure 635-4. Removable Pipe Covering Requiring Glass Felt Spacer

mesh. Insulating cement is trowelled smoothly over all surfaces of the mesh. Covers should be lagged with glass cloth per MIL-C-20079 type I (class as applicable) tightly and smoothly fitted to envelop the outside and ends. Where double layer insulation is used the two sections of the cover should be fitted together with a scarfed joint. Care must be taken in the workmanship to ensure straight and true jointing surfaces of the sections with the view of reducing the heat loss at the joints. Bands and eyelets of galvanized steel are used for securing the cover around the equipment.

3. Rigid covers similar to those described in paragraph 1 above may be made of fibrous sectional pipe-covering (MIL-I-2781) of the same thickness as that on the adjacent piping. The pipe-covering is strong enough so that the wire frames are not required. Each portable insulation piece may be secured to the pipe with two 1/2-inch-wide metal bands or lacing hooks may be installed on rigid covers.

635-1.42 VOIDS UNDER REMOVABLE COVERS. Spaces between removable covers and the surfaces they insulate should be packed with pieces of insulation felt to exclude all air possible. Felt shall be packed loosely enough to preserve air cell structure. On covers which do not fit tightly about the adjacent pipe covering, spaces should be calked with suitable material such as narrow strips of glass cloth.

635-1.43 EXISTING INSTALLATIONS. The foregoing description of the use of removable covers is applicable to the latest construction. Existing installations such as is shown in figure 635-5 need not be changed simply to conform to these requirements but changes made only when replacement is necessary.

635-1.44 PERMANENT FITTING COVERS. Valves, fittings, and flanges not included in paragraph 635-1.40 may have permanent insulation.

1. The following applies to temperatures of 125°F. and up for sizes 3 1/2 inches and under.

a. An all cement insulation may be used. Apply insulating cement, usually in accordance with MIL-C-2861, in 1/2 to 3/4 inch thick layers to cover the bodies, flanges, and bonnets. Each layer of cement must be permitted to dry before the next is applied. Heat should be applied from within as soon as practicable and within 24 hours after installation of the cement to dry out the insulation and avoid corrosion of the metal. After drying, a coating 1/2 inch thick of high temperature cement tempered with Portland cement of equal (4 parts cement to 1 part Portland cement) or a coating of hydraulic setting finishing cement per SS-C-160 type II, grade F, is applied and trowel-rubbed to a smooth finish. Lagging should be in accordance with paragraph 635-1.20.

b. All sizes may be insulated by cutting insulation felt (paragraph 635-1.19) in suitable widths and building up the thickness required to match the adjoining pipe covering, allowing for 1/2-inch of finishing cement. On flanged valves and fittings, the felt should be carried over the flanges to the end of the sectional pipe covering. Spaces that cannot be filled with the layers of material should be filled with loose felt. Layers of felt are secured in position with black or galvanized iron wire and overlaid with one inch square mesh wire screen. A 1/2-inch layer of cement as described in paragraph a. above is applied. Lagging should be in accordance with paragraph 635-1.20. See figure 635-6.

2. For valves and fitting bodies over 3 1/2 inches in size, the bodies only may be permanently insulated as described in 1. above, but the felt is not carried over the flanges; the latter are insulated with removable covers.

635-1.45 COLD WATER AT ALL TEMPERATURES. Valves, fittings, and flanges for cold service do not have removable covers because the insulation must be tight against the penetration of moisture. The following methods are used:

1. Insulate in a manner similar to that described in paragraph 635-1.44 using fibrous glass felt per MIL-I-16411 or MIL-I-22023, or mineral wool felt per MIL-I-2818. Wire should be galvanized. Felt need not be covered with finishing cement. Place a layer of water-repellent and flame-proof paper, per UU-B-790, over the felt; paper should be mitered, lapped, and fitted carefully. Use adhesive cement, MIL-A-3316 class 1, to secure and seal the paper. Lagging and coating should be the same as used on cold pipe (see paragraph 635-1.37). Coating must be blended into the coating on the adjacent pipe to ensure a continuous vapor barrier.

2. Insulate with carefully mitered and fitted foam plastic. All cemented joints must be 100-percent bonded. Cement the fabricated cover to adjacent pipe covering to ensure continuous vapor barrier. Use this method in conjunction with MIL-P-15280 pipe covering (figure 635-7).

635-1.46 REFRIGERANT. As in the case of cold water piping, removable covers are not used on refrigerant piping because of the need for a continuous barrier against penetration of water vapor or other moisture. The following methods are used in making valve, flange, and fitting covers:

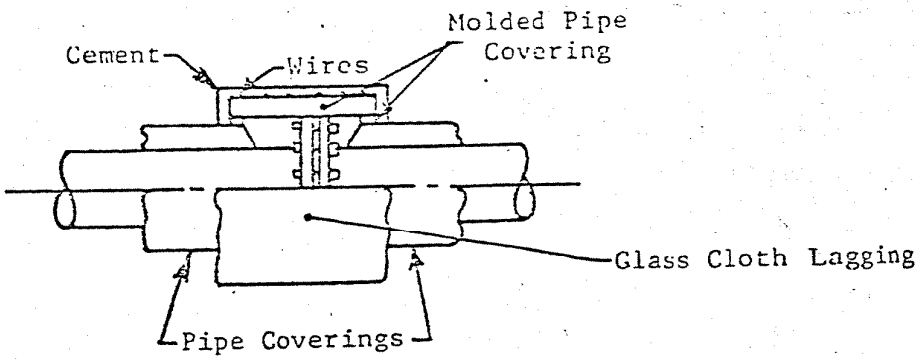


Figure 635-5. Rigid Cover of Wired Block Insulation

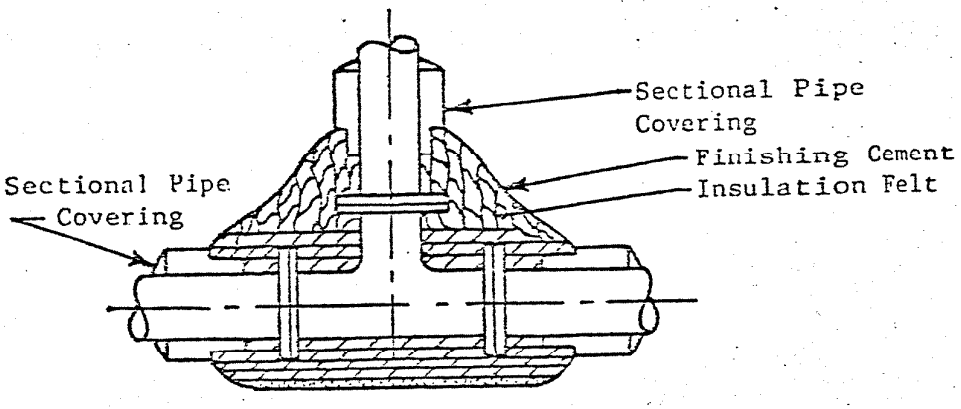


Figure 635-6. Permanent Insulation Using Felt Layers

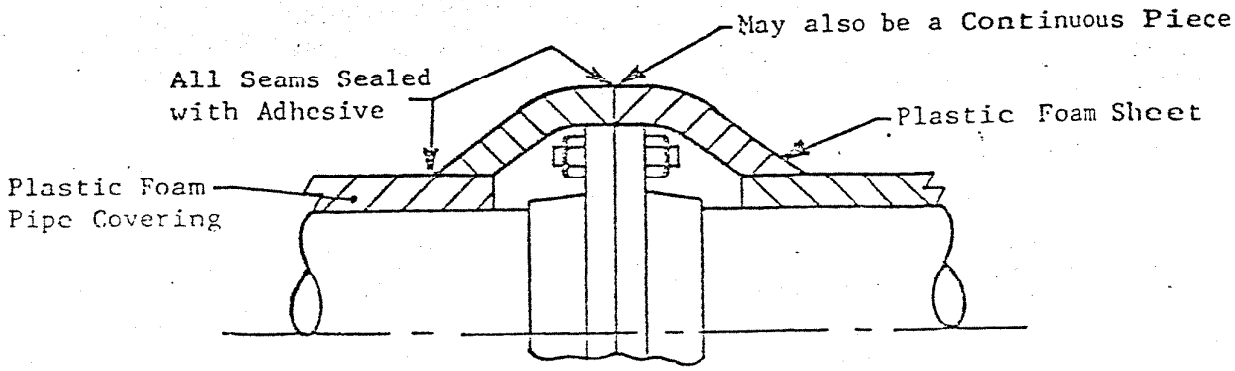


Figure 635-7. Cover Fabricated of Mitered and Fitted Foam Plastic

1. Insulate with fibrous glass or foam plastic in accordance with paragraph 635-1.37.

2. Insulate with cellular glass (HH-I-551) covers. Covers must be fastened, lagged, and coated in the manner described in paragraph 635-1.37 and sealed to the vapor barrier of adjacent piping.

635-1.47 WEATHER-DECK HOT PIPING. Weather-deck hot piping which is to be insulated is first cleaned and dried and made free from scale or grease. Fittings, valves, flanges, and pipe in the way of hangers or clamps are then painted using one coat of pretreatment formula 117, MIL-C-15328, and two coats of aluminum paint made from mixing two pounds of aluminum paste, TT-P-320, type II, class B, with each gallon of phenolic varnish per TT-V-119 for temperatures up to 300°F. Above 300°F, apply two coats of paint per TT-P-28 over the clean bare metal. Each coat is allowed to dry thoroughly before application of the following coat.

1. Cellular glass, HH-I-551 pipe covering is applied as follows:

a. Coat the bore, butt ends, and longitudinal joint surfaces not over 1/16-inch thick with commercial bedding compound, MIL-B-19564, at the time of installation.

b. Place longitudinal joints on horizontal pipe on the top and bottom of the pipe.

c. Secure the insulation with 1/2-inch-wide, 22 gage galvanized steel bands placed over a layer of fibrous glass tape, MIL-C-20079, type II, which has been dipped in coating compound, MIL-C-19565, and wrap the bands with masking tape, UU-T-106, type II.

d. Completely coat the insulating material with coating compound MIL-C-19565, using about two gallons per 100 square feet. Wrap on tightly one layer of open weave fibrous glass cloth, or knitted fibrous glass tape, MIL-C-10079, type II, class 3, and apply another coating of the above compound using about four gallons per 100 square feet. After this coat is thoroughly set, apply another coat of the same thickness.

e. Where insulation is stopped off on the piping, form a tapered section by first coating the pipe liberally with the above bedding compound and forming mineral wool at approximately 30° to the pipe tied in place with galvanized iron wire. Smooth the tapered ends with insulation cement, MIL-C-2861. After the cement has dried, coat the tapered section and three inches of exposed pipe with end-sealing compound, MIL-C-22395. While the sealing compound is still tacky, cover the tapered section with a single layer of glass cloth (MIL-C-20079, type I, class as applicable), tailored to fit the insulation and to extend three inches onto the pipe and the insulation lagging. Attach the cloth to the pipe with a 1/2-inch-wide galvanized steel band and to the lagging with cement, MIL-A-3316, class 1. The tapered section is then covered with a 3/16-inch-thick coating of end-sealing compound. After 72 hours drying time, apply two brush coats of MIL-C-19565 coating half way down the tapered section, allowing 24 hours air-drying time between coats.

f. Where pipe hanger rods penetrate the insulation area, care should be taken to fit the insulation closely to the hanger. Fill voids with tightly packed mineral wool or fibrous glass to 1/4-inch from the surface and finish by filling with end-sealing compound overlapping generously both the support member and the adjacent insulation. The lagging is now applied and coated with the same material as the adjacent piping.

g. Before application of flange insulation, the piping should be thoroughly tested by subjecting it to alternate periods of full operating pressure and zero pressure at ambient temperature. When all leakage has been stopped, permanent covers are shop fabricated and installed in accordance with the above except that small voids may be filled with tightly packed fibrous glass or mineral wool. When specified, rigid removable covers are fabricated to extend 1 1/2 inches over the adjacent insulation. The two halves are lagged and coated separately, the cover is installed, fastened with galvanized steel bands, and completely covered with the above coating compound.

h. Cellular glass is not used on vibrating machinery or piping systems such as steam piping to the whistle.

2. Calcium silicate, MIL-I-2781, pipe covering is installed as described in 1. above except that coating with bedding compound is not necessary.

3. Thickness of weather-deck hot piping shall be in accordance with table 635-10.

TABLE 635-10
NOMINAL THICKNESS OF INSULATION FOR WEATHER DECK HOT PIPING

Pipe Size (Inches i.p.s.)	Calcium Silicate, MIL-I-2781 Cellular Glass HM-I-1751/3
1/4 to 3	1 1/2
3 1/2 to 6	2
over 6	2 1/2

635-1.48 APPLICATION OF THERMAL INSULATION TO MACHINERY

635-1.49 RECIPROCATING ENGINES. Reciprocating engine steam cylinders, valve chests, and other steam enclosing surfaces are insulated with thermal insulation, MIL-I-2819. Insulation thickness shall be as shown in table 635-5. The blocks should be carefully fitted to the metallic surface. Where there are two layers, all joints should be staggered. The blocks should be firmly fastened in place with 1/8-inch galvanized steel cables spaced on 9-inch maximum centers. One-inch mesh, galvanized, wire netting of 18-gage wire is then spread over the surface and held by wiring to the steel cables. All joints should be neatly joined with high temperature insulating cement per paragraph 635-1.19.15, and a layer of 1/2 inch finishing cement to cover the netting and tie wires completely trowelled on smoothly. Cylinders and valve chest are neatly lagged all over with 24-gage, galvanized, sheet steel per paragraph 635-1.20. Upper cylinder heads are insulated as described above but are arranged with cast-steel plates with nonslip upper surfaces instead of sheet-metal lagging. Metal lagging may be secured by using lap joints with a bead on the exposed edge, fastened with hardened self-tapping screws making their own thread in punched holes.

635-1.50 TURBINES. All surfaces of propulsion and auxiliary turbines which have a maximum operating temperature of 125°F. or more should be insulated by one of the methods described in this section. Thickness of insulating material should be as shown in tables 635-5 or 635-6 as appropriate.

1. Surfaces which can be permanently insulated may be covered with sufficient layers of insulation to make up the required thickness. Joints of adjacent layers should be staggered. Layers of felt may be held to one another with adhesive cements per paragraph 635-1.21. Felt should be firmly secured with 1/8-inch, flexible, galvanized, steel cable spaced on 9-inch maximum centers around the outside layer. No holes should be drilled in the casing. One-inch mesh netting of 18-gage, galvanized, steel wire is spread over the felt and secured by 18-gage wire to the cables. A 1/2-inch thick coating of finishing cement per SS-C-160, type III, grade F or of insulating cement, MIL-C-2861, tempered with Portland cement or equal (4 parts insulating cement to 1 part Portland cement) is applied over the netting and trowel rubbed to a smooth finish. After drying 24 hours, an adhesive insulation cement per paragraph 635-1.21 is applied to the hard cement finish and allowed to dry for 1 hour, after which a second coat of the same cement is applied and allowed to dry.

2. Lag the insulation with glass cloth or as indicated in paragraph 635-1.20. Galvanized steel rings backed up by galvanized steel washers fastened on both sides of the lagging should be attached to the permanent insulation adjacent to removable blankets. These blankets are used to cover the flange joint between the upper and lower casings. They are formed by quilting layers of insulation felt together with fine nickel-copper alloy or brass wire. The turbine side of the blanket is covered with 0.008 inch diameter knitted wire mesh of type 304 annealed stainless steel and the outer surface is covered with glass cloth.

3. Blankets are secured to the permanent insulation with 18-gage, galvanized steel or copper wire laced through metal hooks or eyes attached to the edge of the blankets and the rings on the permanent insulation. It is preferable that blankets should project well over the insulation of the adjacent surface. Blankets should be shaped to fit accurately, and spaces between them and the hot metallic surfaces should be completely filled with insulation felt (see figure 635-8).

4. Semi-removable turbine casing flange covers may be installed as an alternate for removable covers described in the previous paragraph. The permanent insulation is run to the casing flange allowing bolt removal space. The flange and bolts then are covered with glass cloth on stainless steel wire mesh, as required by operating temperature, which will be secured to the bolts with wire. The flange now shall be insulated with fibrous glass felt MIL-I-16411, mineral wool felt MIL-I-2818, or insulation block to the required thickness and shape; the insulation is then lagged with glass cloth. This cloth is carried over the outer edge of the permanent insulation and secured with adhesive. The semi-removable cover then is sealed and painted.

5. Thermal block insulation per paragraph 635-1.19 is used for permanent insulation. Prior to applying the block, all irregularities of the turbine surface should be filled to form a smooth surface with high temperature cement. Insulation cement should be used to point up joints between the layers of block and all crevices should be filled. The block covering is held in place by 1/8-inch, flexible, galvanized steel cable spaced on 9-inch maximum centers. The cable may be fastened to steel hooks welded to the casing where required. One-inch mesh netting of 18-gage, galvanized steel wire is spread over the outer layer of block and secured by 18-gage wire to the steel cables. Finishing cement and lagging are applied as described in paragraph 635-1.49. Removable insulation also is the same as outlined in that paragraph.

6. High-temperature insulating cement, as described in paragraph 635-1.19, is sometimes used to

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1. Surfaces which can be permanently insulated may be covered with sufficient layers of insulation to make up the required thickness. Joints of adjacent layers should be staggered. Layers of felt may be held to one another with adhesive cements per paragraph 635-1.21. Felt should be firmly secured with 1/8-inch, flexible, galvanized, steel cable spaced on 9-inch maximum centers around the outside layer. No holes should be drilled in the casing. One-inch mesh netting of 18-gage, galvanized, steel wire is spread over the felt and secured by 18-gage wire to the cables. A 1/2-inch thick coating of finishing cement per SS-C-160, type III, grade F or of insulating cement, MIL-C-2861, tempered with Portland cement or equal (4 parts insulating cement to 1 part Portland cement) is applied over the netting and trowel rubbed to a smooth finish. After drying 24 hours, an adhesive insulation cement per paragraph 635-1.21 is applied to the hard cement finish and allowed to dry for 1 hour, after which a second coat of the same cement is applied and allowed to dry.

2. Lag the insulation with glass cloth or as indicated in paragraph 635-1.20. Galvanized steel rings backed up by galvanized steel washers fastened on both sides of the lagging should be attached to the permanent insulation adjacent to removable blankets. These blankets are used to cover the flange joint between the upper and lower casings. They are formed by quilting layers of insulation. felt together with fine nickel-copper alloy or brass wire. The turbine side of the blanket is covered with 0.008 inch diameter knitted wire mesh of type 304 annealed stainless steel and the outer surface is covered with glass cloth.

3. Blankets are secured to the permanent insulation with 18-gage, galvanized steel or copper wire laced through metal hooks or eyes attached to the edge of the blankets and the rings on the permanent insulation. It is preferable that blankets should project well over the insulation of the adjacent surface. Blankets should be shaped to fit accurately, and spaces between them and the hot metallic surfaces should be completely filled with insulation felt (see figure 635-8).

4. Semi-removable turbine casing flange covers may be installed as an alternate for removable covers described in the previous paragraph. The permanent insulation is run to the casing flange allowing bolt removal space. The flange and bolts then are covered with glass cloth on stainless steel wire mesh, as required by operating temperature, which will be secured to the bolts with wire. The flange now shall be insulated with fibrous glass felt MIL-I-16411, mineral wool felt MIL-I-2818, or insulation block to the required thickness and shape; the insulation is then lagged with glass cloth. This cloth is carried over the outer edge of the permanent insulation and secured with adhesive. The semi-removable cover then is sealed and painted.

5. Thermal block insulation per paragraph 635-1.19 is used for permanent insulation. Prior to applying the block, all irregularities of the turbine surface should be filled to form a smooth surface with high temperature cement. Insulation cement should be used to point up joints between the layers of block and all crevices should be filled. The block covering is held in place by 1/8-inch, flexible, galvanized steel cable spaced on 9-inch maximum centers. The cable may be fastened to steel hooks welded to the casing where required. One-inch mesh netting of 18-gage, galvanized steel wire is spread over the outer layer of block and secured by 18-gage wire to the steel cables. Finishing cement and lagging are applied as described in paragraph 635-1.49. Removable insulation also is the same as outlined in that paragraph.

6. High-temperature insulating cement, as described in paragraph 635-1.19, is sometimes used to

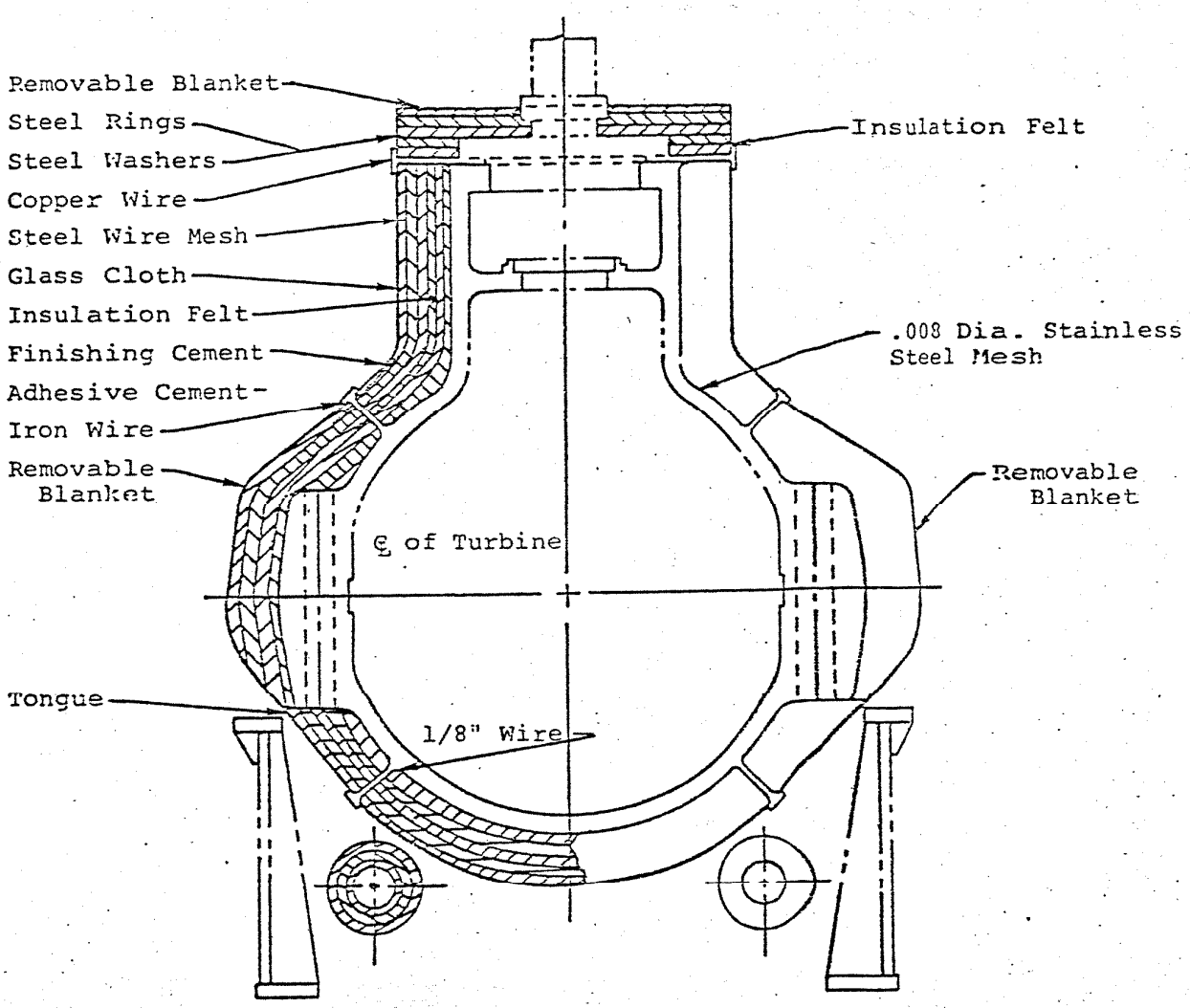

Figure 635-8. Removable Blankets Secured to Turbine Permanent Insulation

form the complete permanent insulation. It is applied in layers less than 1 inch thick and is reinforced with wire mesh. Each layer must be permitted to dry thoroughly before applying more cement. Finishing cement and lagging are applied as indicated in paragraphs 1 and 2 above. Removable insulation is the same as outlined in that paragraph.

635-1.51 BOILER STEAM DRUMS, WATER DRUMS, AND HEADERS. For insulation of boiler casings and refractory linings refer to chapter 221 (9510).

1. Refer to tables 635-5 and 635-6 for thickness of insulation.

2. Drum shells may be covered with sufficient layers of insulation felt per paragraph 635-1.19 to make up the required thickness. The method described in paragraph 635-1.49 should be followed. Figures 635-9 and 635-10 show a typical installation including the manhole cover of insulation felt enclosed in a container made of 16-gage sheet metal per paragraph 635-1.20.2. Metallic lagging of 20-gage, galvanized sheet steel is used as shown in figure 635-11. The sheet steel is fastened with 1/4-inch machine screws to 1/4- by 1-inch flat bars

bent to a suitable radius and imbedded in the finishing coat of cement.

3. Another method is to follow the procedure outlined in paragrah 635-1.49 using insulating material per paragraph 635-1.19. The type secured between 1-inch wire mesh and expanded lath should be used; the latter side should face outward. The drum ends may be insulated with high-temperature insulation cement of the rock or mineral-wool type described in paragraph 635-1.19. Each layer of cement should be between 3/4 and 1 inch thick and allowed to set for 24 hours or until dry. The manhole cover and the lagging should be of the type described in paragraph 2. above.

4. Block insulation may be used for drum shells. Materials are described in paragraph 635-1.19. Also large-size segmental pipe covering may be used. Application of this type of insulating material is outlined in paragraphs 635-1.49 and 635-1.50. The drum heads may be insulated with insulation felt or higher temperature cement as described in paragraph 635-1.50.

5. Superheater headers may be insulated with custom-made blankets of insulating felt, lagging, and wire mesh. These blankets are laced to studs welded to the super-heater support plate in the area of holes which are covered with pads of the same construction. Downcomer tubes and soot-blower piping should be insulated in accordance with paragraph 635-1.28 which covers pipes and tubing.

635-1.52 UPTAKES. Uptakes and breechings are constructed with an inner and outer casing between which the insulating material is placed.

1. Glass fiber batts described in paragraph 635-1.19 may be used. It may be secured in place by wiring it to T-bars which are suitably spaced and attached to the inner casing. Also it may be secured by impaling it on studs used to support the outer casing. Galvanized steel washers may be placed on the studs to hold the batts in place until the outer casing is installed.

2. Mineral wool blanket insulation per paragraph 635-1.19 also may be used for insulating uptakes. It should be wired in place with separate pieces butted closely together.

635-1.53 LOW PRESSURE DISTILLING PLANT. The evaporator shells and the upper half of the evaporator ends, the vapor feed heaters, and air ejector condensers shall be permanently insulated with insulating felt and cement with lagging in the manner described previously in paragraph 635-1.50.

1. The lower half of the evaporator ends shall be covered with removable insulating felt blankets of the type discussed in paragraph 635-1.50. Refer to table 635-5 for recommended thicknesses of insulation. The removable blankets fixed to 22-gage, galvanized sheet steel covers are made in sections to suit the installation. Sections shall be held together and to the evaporators with 1/4-inch machine screws or self-tapping screws. The blankets shall be secured to the metallic lagging by 18-gage, galvanized or copper wire through rings attached to the blankets and hooks welded to the steel lagging.

2. The condensate cooler shall be covered as is required for cold water service with a 1-inch-layer of insulation felt and cement in the same manner as the aforementioned apparatus. The cement shall be covered with one layer of water-repellent and flameproof sheathing paper with vapor seals as instructed in paragraph 635-1.37 and lagged with glass cloth.

635-1.54 INSULATION INSPECTION

635-1.55 INFRARED THERMOMETER METHOD. On recognized method widely used for determining the effectiveness of installed insulation is to measure the insulation surface temperature by means of an infrared thermometer or heat gun.

1. The inspection of insulation, investigation of surface temperatures, and location of hot spots can be readily accomplished by use of the heat gun. The heat gun is a non-contact instrument that indicates surface temperatures without the hazards associated with contacting these hot surfaces. The heat gun may be used in shipboard fireroom maintanance programs and also in Pre-Overhaul Tests and Inspections (POT&I's) to identify and define insulation replacement requirements.

2. Hand-held heat guns are commercially available from various sources. (Refer to table 635-11.)

635-1.56 USE OF HEAT GUN. To obtain measurements of insulation surface temperatures, proceed as follows:

1. The infrared thermometer or heat gun should be carefully checked and calibrated in accordance with the directions provided with the instrument. Particular importance must be given to checking for the proper emissivity setting. The following emmissivities shall be used in conjunction with this procedure:

a. Navy white paint (clean) - 0.9

b. Navy aluminum paint (clean) - 0.4

Additional emissivity values are provided with the instrument.

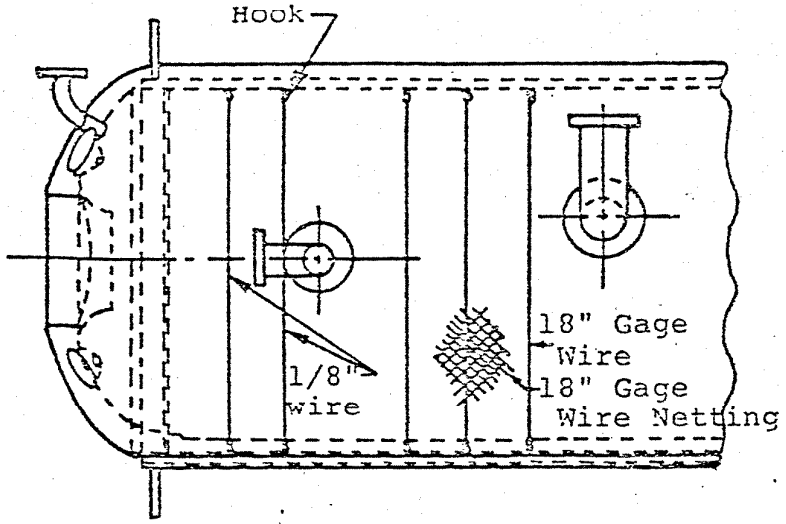

Figure 635-9. Typical Drum Shell Insulation Covering

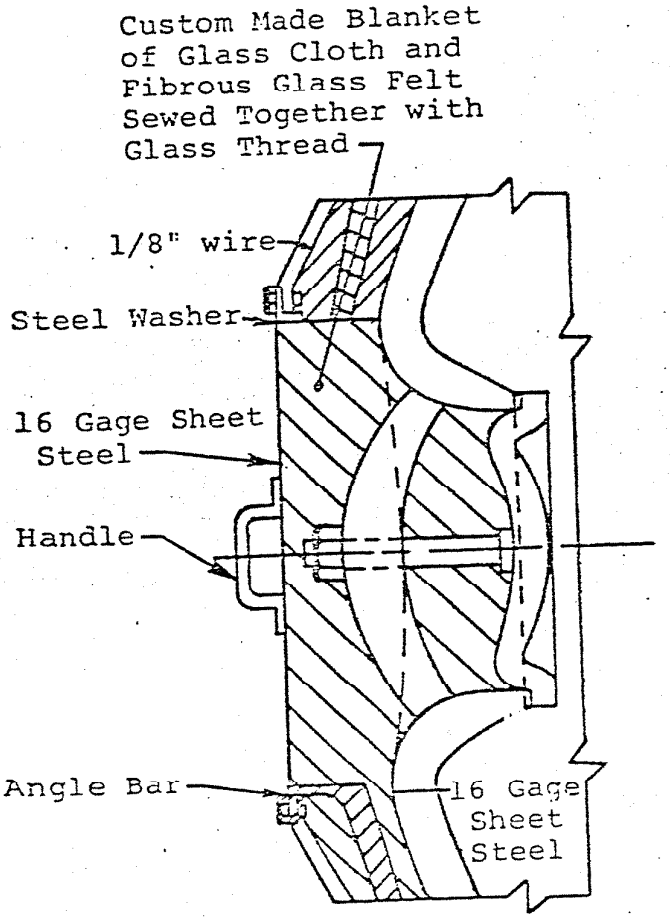

Figure 635-10. Drum Shell Showing Insulated and Steel-Encased Manhole Cover

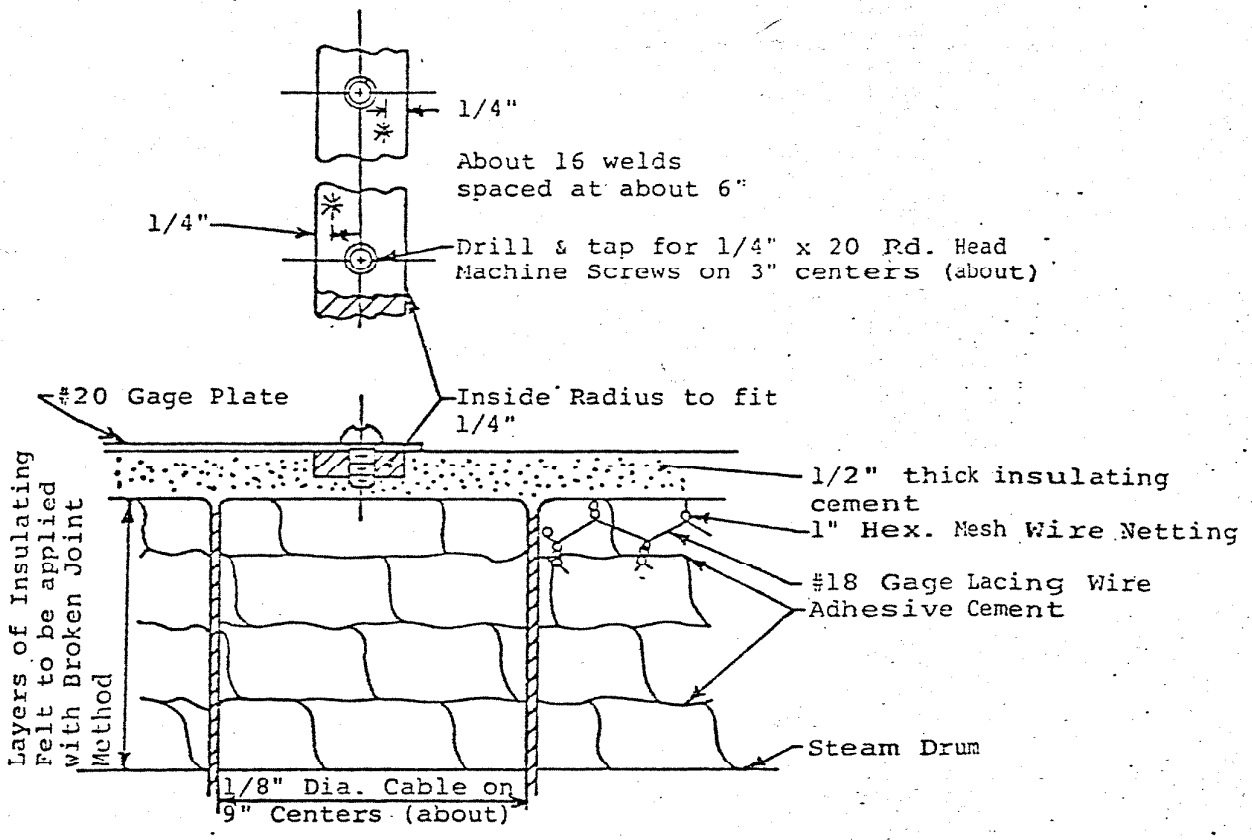

Figure 635-11. Application of 20-Gage Metallic Lagging

WARNING

Dust producing materials such as asbestos can be hazardous to your health. Refer to safety precautions (paragraph 635-1.13) as appropriate.

2. The heat gun is sighted on the object to be inspected by use of a sight which is built into the instrument. Heat gun readings shall be recorded for each location tested. Ambient dry bulb readings in proximity to the surface being inspected shall be measured and recorded for each location being inspected. When inspecting piping systems the pipe run can be scanned with the gun. When a location with deteriorated insulation (hot spot) is passed the readings will increase significantly. This location should be recorded as requiring replacement insulation.

NOTE: Items (or systems) being inspected should be operating normally and should have reached normal operating temperatures.

NOTE: When not in use, the infrared thermometer is to be stored in an area having an ambient temperature of 100°F or less.

NOTE: If the infrared thermometer cannot be set to zero, place instrument in cool air stream until the instrument stabilizes and then proceed with readings.

3. Determine system fluid temperature or identify system by name. (See figure 635-12.)

4. Enter figure 635-12 for each location being inspected with either fluid temperature or system description and ambient dry bulb temperature; read maximum allowable surface temperature. This is accomplished by the following process (an example is provided for clarification):

Step 1: Enter figure 635-12 at operating temperature or system description and traverse horizontally across graph until reaching intersection with the proper ambient temperature line (deter-

TABLE 635-11

HEAT GUN SPECIFICATIONS

SOURCE	WILLIAM WAHL CORP.* 12908 PANAMA ST. LOS ANGELES, CALIF. 90066		WILLIAMSON CORP.* 1152 MAIN ST. CONCORD, MASS. 01742	
Model No.	DHS-14	HSA-1E	2220B	600
Readout	Digital	Dial Meter	Digital	Dial
Temperature Range (^{o}F)**	0-600	0-600	125-600	125-600
Working Distance	0-20 Feet	0-20 Feet	6" to infinity	1 ft to infinity
Response Time (sec)	1	1	0.3	0.3
Emissivity Range	0.2-1.0	0.2-1.0	0.4-1.0	0.4-1.0
Weight (lbs)	3	3	3-1/2	2-3/4
Price (Subject to Change)	CONTACT MANUFACTURER			

*or equivalent manufacturer

**Units should be suitable for ambient temperature of 125^{o}F at continuous operation.

mined by measurement of air temperature in vicinity of surface in question).

Step 2: From the point of intersection of the system fluid temperature and the measured ambient temperature, traverse vertically down and read the maximum allowable surface temperature.

EXAMPLE

System: Main steam, saturated, 1200 psi, 570°F

Ambient temperature: 100°F

Execute Step 1: Reach intersection point "0" on Figure 635-12.

Execute Step 2: Traverse vertically down from point "0".

Read maximum allowable surface temperature: i.e., 140°F.

5. Compare the maximum allowable surface temperature derived from figure 635-12 for the given location with the recorded heat gun reading corresponding to the same location.

a. If the recorded heat gun temperature is less than the maximum allowable, the insulation is satisfactory and no further action is required.

b. If the recorded temperature exceeds the maximum, initiate the appropriate corrective action.

NOTE: Figure 635-12 allows for insulation and lagging deterioration. No additional allowances should be provided.

635-1.57 CORRECTIVE ACTION. The following corrective actions, as appropriate, shall be initiated if the heat gun measured temperature exceeds the calculated maximum surface temperature derived from figure 635-12.

1. Check for missing or deteriorated insulation on adjacent pipes or surfaces. If this condition exists insulate these surfaces and reinspect the original surface per the procedure defined in paragraph 635-1.56.

WARNING

For safety precautions prior to removal or replacement of cloth lagging or insulation, refer to paragraph 635-1.13.

2. Replace insulation and lagging if missing, damaged, or crushed.

3. If insulation is found to be oil or water soaked, remove all affected insulation, repair source of oil/water leak, and replace insulation.

4. Repair or replace insulation found to be loose or improperly installed.

5. Reinspect insulation per procedure outlined herein.

SECTION 2 INSULATION OF COMPARTMENTS AND DUCTS

635-2.1 GENERAL -

635-2.2 SCOPE. This section covers the utilization of thermal insulation and acoustic absorption treatment on the structure of ships and their ventilation and air conditioning systems.

635-2.3 SAFETY PRECAUTIONS. Safety precautions must be rigidly adhered to when handling dust producing materials such as asbestos and fibrous glass (see paragraph 635-1.13). Permissible levels of exposure, hygenic control measures, protective equipment, medical surveilliance requirements, and other pertinent data governing occupational hazards involved in applying, removing, using, handling, storing, processing, disposing, or transporting materials which contain asbestos receive thorough coverage in Appendices A, B, and C.

635-2.4 THICKNESSES OF INSULATION. The rate of heat flow through any homogeneous material such as thermal insulation is inversely proportional to the thickness. When installed, however, the insulation can no longer be considered as homogeneous since the structure to which it is secured and the air films on either side of the composite structure-and-insulation must be considered. Because of this, equal increments in the thickness of insulation do not yield equal reductions in rate of heat transfer. Practically, this consideration means that small variations of insulation thickness do not materially affect the rate of heat flow and corresponding ventilation air volumes which are required. As a result, it has been possible to adopt uniform thicknesses of insulation for varying rates of heat transfer at different temperature levels.

1. The thicknesses in general use are:

a. One-inch material is generally used in ammunition spaces, miscellaneous stowage spaces, and on the weather and sea boundaries of spaces whose ambient temperature is under 105°F.

b. Two inches of material is generally

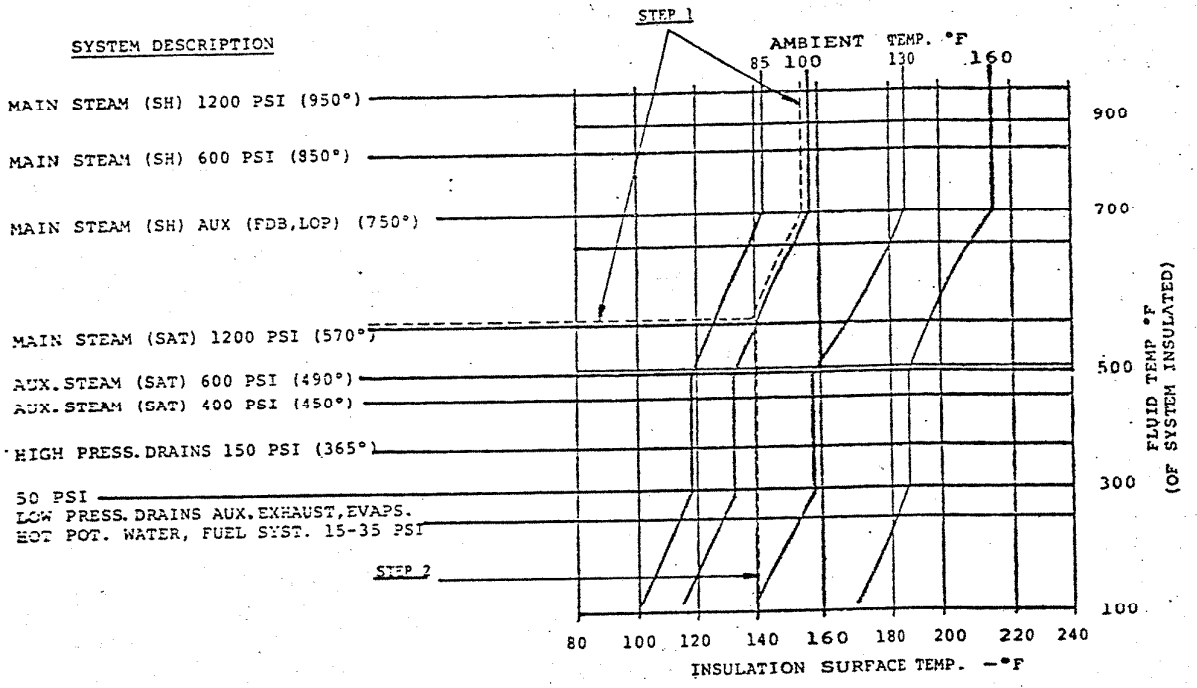

Figure 635-12. Maximum Allowable Surface Temperature

used on weather and sea boundaries of spaces whose ambient temperature is over 105°F and between heat-producing spaces and air-conditioned spaces.

c. A minimum of six inches is used for refrigerated spaces other than 0°F freeze rooms (fibrous type insulation).

d. A minimum of nine inches is used for 0°F freeze rooms (fibrous type insulation).

e. One inch is used for ventilation and air conditioning ducts requiring insulation.

f. Other thicknesses are installed to meet special conditions. If there is any question as to thickness when replacing insulation, the insulation plans for the vessel should be consulted. For new designs, the thicknesses of insulation are specified in the detail specifications for the particular ship. In the absence of any specific instructions, the aforementioned thicknesses are acceptable.

2. Acoustic absorption treatment. One-inch-thick sound absorption treatment normally is installed on ventilation and air-conditioning ducts except where greater absorption is required, in which case two inches may be required. Two-inch thick treatment is used for compartments.

635-2.5 HULL THERMAL INSULATION

635-2.6 APPLICATIONS. Hull thermal insulation is the term given to the insulation which is applied to the shell, bulkheads, overhead, and the structural members of these components of a ships hull to differentiate it from the thermal insulation applied to piping, equipment, refrigerated spaces, and ducts.

635-2.7 MATERIALS. Hull insulation used on naval surface ships and on certain boundaries of submarines consists of fibrous glass insulation board conforming to MIL-I-742, type I. Hull insulation is stocked in the Naval Supply System in 24-inch by 36-inch boards. This size has been found to be most useful, generally, for new construction, maintenance, and repairs. However, there are instances where the use of nonstandard widths, tailored to specific ships may be more economical because of reduction in cutting and fitting and in the amount of waste material during installation. Non-standard sizes may be obtained on special order.

635-2.8 Surface Ships. Fibrous glass tape used for covering the seams formed by the adjacent panels of type I insulatin board conforms to MIL-C-20079 type II, class 1, without resin treatment, and is secured to the insulation board with adhesive, MIL-A-3316, class 1.

1. Types I and II insulation boards are attached to the ships structure by use of studs conforming to MIL-S-24149 and fasteners shown on NAVSEA Drawing No. 805-1343696. In certain areas, the insulation boards may be secured to the ships structure by use of adhesive-attached studs in lieu of welded studs. The number of adhesive attached studs may not exceed 25 percent of the total number of studs required to secure each section of board. These adhesive-attached studs are in general accordance with MIL-S-24149, except that the studs as procured are welded to a base plate, at least two-inches square, of the same metal as the stud. The studs, bonded with adhesive to the ships structure withstand 400 pounds tensile pull without failure of the bond.

2. Vapor barrier coating compound, conforming to MIL-19993, is applied over the exposed surfaces of the fibrous glass hull insulation board installed in drying rooms, where because of large differences in temperature or high humidities, condensation is apt to occur.

635-2.9 Submarines. Hull insulation used on submarines to insulate the pressure hull consists of elastomeric foamed plastic insulation conforming to MIL-P-15280. One inch thick material is applied to the pressure hull and webs of internal frames and one-half inch thick material for flanges of the internal frames.

1. Adhesives for securing flexible unicellular plastic insulation MIL-P-15280 (hull and piping) is a material which complies with the requirements of MIL-A-24179, type I or II.

2. Grouting material used with elastomeric foamed plastic insulation is normally 30% by weight, Spackle, with 70% Arobol cement or equal (SS-J-570 and MIL-A-3316, class 1, respectively).

3. Insulation for hard tank tops which form part of a deck or walking flat on a submarine shall be one-inch thick fibrous glass insulation under a 1/4-inch thick steel canning plate.

635-2.10 INSTALLATION. Preparation of the surface on both surface ships and submarines shall be in accordance with chapter 631 (9190).

635-2.11 Surface Ships. The metal boundary, which is to be insulated, is inspected to determine that the protective coating is intact and the surface is free of any grease or dirt. Where necessary, the metal surface should be touched up as specified in chapter 631 (9190). At the time the surfaces are inspected, measurements should be made of the structural members whose flanges and webs are to be insulated. Prefabrication of insulation into wrapping has been found to be the best method of covering

structural members, since a minimum of cutting and fitting is thereby required.

1. The method consists essentially of cutting V grooves, properly spaced, removing the loose strips of board and then bending to shape for fitting around the flanges and webs. If type I insulation board is used to insulate the structural members, the kerf-cutting knives are adjusted to reach just below the cloth facing.

2. There are two acceptable methods for securing the board to the structure. In one, the studs are laid out and welded in place on the structure, with due regard to the number required and dimensions and contour of the section of board to be installed. The board is then impaled over the studs. In the other method, each section of board is first fitted into place, and locations of the studs determined by punching through the board to mark the metal. The board is then removed, the studs welded, and the board then slipped over the studs through the holes previously formed. In both methods, after the board is in place and pressed firmly against the structure, the fasteners are secured over the studs. Studs shall be spaced approximately 12 inches apart on centers. Studs at edges of board shall be placed not more than 6 inches from the edge. Sufficient studs must be used to hold the board firmly and evenly against the structure. In areas where additional or replacement insulation studs are required, and in areas which are not accessible for use of the stud welding gun, adhesive-attached studs may be used for securing fibrous-glass insulation board in lieu of the welded studs. The number of adhesive-attached studs may not exceed 25 percent of the total number of studs required to secure each section of board (see paragraph 635-2.8). When a cut-out is made in hull insulation in order to weld a stud onto the bulkhead or overhead, it is not necessary to fill the space around the stud with insulation unless the space left around the stud is more than 5/16 inch on all sides. The 5/16 inch or smaller space may be covered with fibrous glass tape or a metal cap. Spaces in excess of 5/16 inch shall be filled with fibrous glass insulation covered with fibrous glass tape or a metal cap.

3. When insulation board is installed, fibrous glass tape is applied over the seams where the boards are butted together and secured to the board facings with adhesive conforming to MIL-A-3316, class 1.

4. After the board is installed, it is painted to match the other surfaces in the compartment.

5. Vapor barrier coating compound, MIL-C-19993, shall consist of three alternate coats of white, orange, and white, applied to the face, four edges, and two inches of the periphery of the soft surface of each separate section of insulation board before installation. The above compounds are installed on the warm side of refrigerated space boundries and in drying rooms. After installation, all seams shall be coated, and punctures in the vapor barrier (such as in way of studs) shall be touched up with three coats. No holidays should exist in any single coat of vapor barrier coating compound.

6. Details of the installation of thermal insulation in compartments are shown on NAVSEA Drawing No. 805-1749057, with the exception that glass cloth per MIL-C-20079, type I, class 2, shall be used in lieu of brattice cloth.

635-2.12 Submarines. Elastomeric foam plastic insulation MIL-P-15280 shall be installed to the submaring pressure hull as follows:

1. Structural surface shall be prepared in accordance with chapter 631 (9190). The surface to be insulated is coated with adhesive and allowed to dry from two to five minutes or until tacky.

2. The insulaton is then cut to desired size, the cut edges coated with adhesive and when tacky the insulation is pressed into place. No shoring is required.

3. Any voids between adjacent sheets of material or in way of penetrations for hull attachments are filled with grouting. When completely dry, the grouting shall be sanded smooth and the surface of the insulation is cleaned of any dirt or foreign material. Except for those areas completely covered by outboard paneling or overhead sheathing, all surfaces of installed insulaton shall be painted in accordance with chapter 631 (9190).

635-2.13 MAINTENANCE. Where the Planned Maintenance Subsystem (PMS) is installed scheduled maintenance shall be conducted in accordance with the Maintenance Requirement Card (MRC) set.

1. Hull insulation should be inspected at least at semiannual intervals together with other portions of the hull structure. Areas behind insulation on weather and sea boundaries of ships operating on cold waters (below 40°F) and in ammunition spaces, where condensation is likely to occur, should be inspected during overhauls to ensure that corrosion has not occurred on ships structure. Action should be taken to have all damage, including that considered as minor, repaired at once since prompt repair will forestall development into major repair jobs.

2. In case of water damage, hull insulation shall be replaced.

635-2.14 REPAIR. The following procedure shall be used for repair of hull insulation.

635-2.15 Surface Ships. Two procedures for repair of damaged fibrous glass insulation board have been established; one for accomplishment by ships forces, and the second by qualified repair activities.

1. Each ship fitted with fibrous glass insulation board has an allowance of fibrous glass tape and class 1 adhesive for shipboard repair of small tears, dents, gouges, and similar damage to the insulation. Application of the tape will, in most instances, prevent further damage and ensure the continued serviceability of the insulation until the next overhaul of the vessel when, if warranted, more extensive repairs can be made.

2. For extensive repairs to the insulation, in most instances the insulation may, in lieu of being replaced, be repaired economically with a resultant condition at least equal to that of newly installed board. The method is based on the fact that most damage occurs initially to the cloth surface, and leaves the body of the board relatively intact.

a. Before the cloth covering is applied, the damaged insulation shall be prepared as follows:

(1) Missing studs are replaced.

(2) Minor cuts, tears, and dents are repaired.

(3) Studs and fasteners are covered with small patches of cloth in order to provide a uniform foundation for the overall cloth.

b. After the damaged insulation has been prepared, glass cloth conforming to MIL-C-20079, type I, class 2 is cut to fit a suitable section of the area to be covered. A typical application would take a single piece of cloth from deck to overhead between structural members. The corresponding section of insulation is given a coat of adhesive, conforming to MIL-A-3316, class 1, applied with either a brush or trowel, and the cloth is set in place and pressed smooth. A top coat of adhesive is then applied on the cloth as heavily as necessary to fill all the interstices of the cloth and ensure the adherence of the cloth.

635-2.16 Submarines. Repair of elastomeric foam plastic used for submarines, shall be as follows:

1. Cut out and remove damaged insulation. Adhered fragments of insulation shall be removed by scraping. Structure does not need to be cleaned to bare metal except in way of newly welded attachments where loose slag or other surface contaminants may be present. Care should be taken in cutting replacement insulation to ensure a neat fit with abutting insulation.

2. Reinstallation of material is to be in accordance with paragraph 635-2.12.

635-2.17 ANTISWEAT TREATMENT

635-2.18 MATERIALS. Material normally used to prevent sweating of cold surfaces is vermiculite paint. Methods of application are covered in chapter 631 (9190). Antisweat coating, TT-C-492 may be used as an alternate to vermiculite.

635-2.19 APPLICATIONS. Vermiculite paint (refer to chapter 631 (9190)) is applied on the warm side of uninsulated boundaries, including webs and flanges of beams and stiffeners.

1. This paint is applied on:

a. Interior surfaces, including uninsulated flanges, of all spaces, except tanks, voids, and heat producing spaces, exposed to the sea or weather, or where sweating will occur because of opposite extremes in temperature.

b. Deck under, and all vertical boundaries of air conditioned spaces common to spaces that are not air conditioned.

c. Exterior surfaces of water tanks in way of all spaces except voids.

d. Hangers, brackets, clips, and other members secured to or penetrating boundaries exposed to the sea and where dripping will affect electric installations.

2. Antisweat coating TT-C-492 may be used in the above areas (except as noted below) where vermiculite does not satisfactorily prevent condensation. This material performs on the principle of absorption and evaporation. Condensation, which forms on the surface of the coating, is absorbed. This process continues until the coating becomes saturated (at which time sweating will appear) or until the ambient conditions change permitting reevaporation or release of the moisture back into the air. Since the material will absorb fluids, it may not be installed in areas where it is subject to oil spills, sprays, etc., since this will contaminate the material, impair its effectiveness, and eventually constitute a fire hazard. It may not be used in flooded areas or locations which are subject to severe abrasion as this also will result in failure of the material to perform satisfactorily. Surface preparation and application procedures are covered in the aforementioned specification.

635-2.20 REFRIGERATED STORES SPACES

635-2.21 APPLICATIONS. The refrigerated stores spaces are insulated so that they may be maintained at the low temperatures required for proper preservation of the perishable foods carried. On nearly all ships, built-in refrigerated stores spaces (as distinguished from reach-in refrigerators used in ships pantries and galleys) are provided, although the number

and size of the individual spaces vary from ship to ship. Typical refrigerated stores spaces are 33°F chill rooms, 0°F freeze rooms, and multipurpose 0° - 33°F spaces which can be used, either for chill or freeze rooms. In some cases, refrigerated stores space vestibules are used as thaw spaces and are insulated in accordance with the requirements for refrigerated stores spaces. Generally, walk-in or thaw regrigerators are installed in the galley or butcher shop.

635-2.22 MATERIALS. There are several types of construction that may be used for refrigerated spaces. Typical constructions involve the use of fibrous glass, mineral wool or polyurethane insulations covered with a sheathing of wood, hardcore marine veneer, metal or fiberglass reinforced fire resistant resin laminate. Mineral wool insulation is no longer used but may be found on some older ships. Polystyrene insulation should not be used.

1. Insulation. Insulating materials currently used in the constructions of new naval shipboard refrigerated spaces are fibrous glass conforming to MIL-I-22023, type I, class 5; or polyurethane foam, MIL-I-24172, either type I (preformed) or type II (foamed-in-place). Polyurethane insulation used on bulkheads and overheads shall be nominal two pounds per cubic foot density. For decks underfoot, the polyurethane form shall be nominal four pounds per cubic foot density. The insulation thickness should be sufficient to maintain easily the specified temperatures at the outside design conditions without sweating on the exterior surfaces of the refrigerated space boundaries.

2. Sheathing (inner lining). Various sheathing materials are used for the bulkheads and overheads. Metal sheathing may be either corrosion resistant steel, QQ-S-766, class 304 with 2B finish, or cold rolled nickel-copper alloy sheet, QQ-N-281, class A, satin finish. Fibrous glass reinforced fire resistant resin laminate sheathing may be either 3/16 inch thick sheets to MIL-I-17349, grade W, or commercially available expanded metal inserted resin laminate expressly designed for refrigerated space application and known by the trade name Bailite by Baily Refrigeration Co. or Reeferon by Plymold Co. Hardcore marine veneer sheathing may also be used consisting of aluminum sheet sandwiched between sheets of marine veneer and known commercially as Reeferite by Johns-Manville Co.

3. Deck covering. Refrigerated space deck insulation may be protected with a covering of metal or fibrous glass reinforced resin laminate similar to the types used on bulkheads and overheads or may be covered using concrete with a latex mastic coating, MIL-D-313, type II, or the insulation may be protected with a concrete-mastic mix consisting of 1 part Portlant cement, 1 part mastic, 2 parts sand, and 3 parts grit (gravel). The mastic is odorless and similar to Flintkote No. N-13-HPC.

4. Furring and framing. Furring and framing material should preferably be wood; however, structural grade fibrous glass reinforced resin laminate or metal may also be used. Wood furring and framing including the preservative treatment of same should be in accordance with table 635-12, fibrous MIL-P-17549, grade W.

5. The materials specified above may be specified on all ships except that non-magnetic materials are specified for use on minesweepers.

635-2.23 GENERAL INSTALLATION TECHNIQUES. Before any insulation or sheathing is installed in refrigerated stores spaces, the structural bulkheads and decks are tested for airtightness. In addition, the ships structure and sheathing supports are painted or otherwise treated in accordance with chapter 631 (9190) prior to installing insulation.

1. Bulkheads and overhead. Furring and framing to support sheathing and equipment should be installed first and should be bolted directly to deck beams, frames, and stiffeners or to flat bar clips welded to ships structure. Fastenings such as bolts, lag screws, wood screws, etc. are hot-dipped galvanized and so arranged to prevent metal to metal contact between sheathing and structure. Where metal furring and framing is used it should be isolated from the ships structure by use of phenolic or fibrous glass reinforced resin laminate blocks.

a. Framing for each side of non-structural division bulkheads between refrigerated spaces is made independent of the other side by staggering frames. No through framing is permitted.

b. Supports for coils and unit coolers are integrated with the system of furring and framing. Supports should be independent of lining.

c. Insulation should be closely fitted and adequately held in place usually with skewers until the sheathing is installed. (No studs or pins are permitted.) Preformed polyurethane block insulation where used is secured to the structure and to adjacent blocks with adhesive. The entire space between the sheathing panels and ships structure should be filled with insulation, installed in such a manner as to eliminate voids. Where insulation is installed in multiple courses the butts and seams of each course are staggered against the prior course.

d. Sheathing for bulkheads and overhead is fastened to the furring and framing with stainless steel screws. Seams between sheathing panels should in the vertical plane only and covered with 2 inch wide seam straps fastened with stainless steel screws.

TABLE 635-12

FURRING AND FRAMING MATERIALS

Use	Wood	Grade*	Preservation
Framing	Southern Pine Douglas Fir	No. 1 Dimension	TT-W-571, Table III. For use under moderate weathering conditions. Ammoniacal Copper Arsenite or Chromated Copper Arsenite only
Sheathing (Under Coarse)	Southern Pine T&G	No. 1 Boards	Same as above
	West-Coast Hemlock	Select Merchantable	Same as above
	Douglas Fir T&G	Select Merchantable	Same as above
	Plywood T&G	Structural I C-D	Same as above
Sheathing (Exposed Coarse)	Southern Pine T&G	C Flooring	No treatment
	Douglas Fir T&G	Select Merchantable	No treatment
	Plywood	"B-C Exterior" or better	No treatment
	West-Coast Hemlock, T&G	Select Merchantable	No treatment

*Southern Pine Inspection Bureau, West Coast Lumber Inspection Bureau or Product Standard PSI-74, as applicable

A 1 x 1 x 1 inch Z shape is fitted between the sheathing bottom and the deck cove. All inside and outside corner seams of the sheathing are covered with 1 x 1 inch angles fastened with stainless steel screws. Where reinforced resin laminate sheathing is used, the seam straps, Z shape, and corner angles should be 0.081 inch aluminum.

e. Bulkhead sheathing is made watertight to 12 inches above the finished deck.

2. Deck underfoot. For decks underfoot the insulation may be fibrous glass or preformed polyurethane. Where preformed polyurethane block insulation is used the polyurethane should be installed in at least two courses. The deck is coated with odorless asphalt emulsion, Flintkote, C-13-HPC, or equal, prior to installing the first course of polyurethane block. The top of each course of block, including the final course, should be coated with the asphalt emulsion. Each course is staggered against the prior course with two adjacent edges of each block being coated with the asphalt emulsion. The block type insulation should extend up the sides 12 inches above the full deck insulation. A three layer vapor seal membrane of 15-pound felt paper, each laid in and covered with asphalt emulsion, is applied over the insulation and extends up the sides to completely cover the block insulation.

a. When metal deck sheathing is installed it is fastened to a system of furring and framing isolated from the ships structure. When fibrous glass reinforced laminate is used it is laid in two 3/16 inch thick layers, completely bonded to each other with staggered joints flush with the deck. The joint between the bulkhead and deck sheathing is made watertight.

b. Where concrete with a mastic coating is specified, 1-1/2 inches of concrete is laid over the emulsion covered felt paper, with 2 x 2 inch galvanized wire mesh reinforcement embedded therein. A coating of 1/2 inch of mastic is then applied over the concrete and covered up the sides 6 inches and flushed with the bottom of the side sheathing. Where ratproofing is required the asphalt paper waterproof 6 inch latex mastic deck covering cove is

reinforced with 1/2 inch by 18-gage galvanized wire mesh 4 inches out on the deck and up to bottom of the bulkhead panels.

c. When a concrete-mastic mix is the deck covering specified it should be at least 2 inches thick and should be applied over the emulsion covered felt paper vapor seal membrane.

d. The finished decking is coved up the sides 6 inches so as to be flush with the bottom of the sheathing.

e. Reinforcement is 2 inches x 2 inches x 14-gage galvanized steel wire mesh. The method of laying the finished decking should be such as to prevent cracking or shrinking while setting. The finish decking should be thoroughly set before the spaces are pulled down in temperature. Where ratproofing is required the cove is reinforced with 1/2 inch by 18-gage galvanized wire mesh 4 inches out on the deck and up to the bottom of the bulkhead sheathing.

635-2.24 BREATHER OPENINGS. Water vapor in warm air exhibits a pronounced tendency to migrate to colder air. Whenever the temperature at any point within a partition becomes lower than the dew point of the air, condensation of the water vapor tends to occur at that point. In refrigerated stores spaces where mineral wool or fibrous glass insulation is used, the dew point is usually located somewhere in the insulation. The presence of water in the insulation is undesirable since it reduces the efficiency of the insulation.

1. Since the coldest air is at the coils, moisture, if present in the insulation, will migrate to the coils provided a path of migration is provided for. In ships where the inner sheathing in the refrigerated spaces is welded watertight, breather openings with plugs or caps must be provided in the sheathing. Where the joints between sheathing panels are butted together and panel edges are held to the furring by screws there is sufficient opening to provide a natural migration path for the moisture.

2. The breather plugs are inserted in the breather openings when defrosting or washing down the spaces in order to seal the sheathing, prevent moisture from entering the fibrous glass insulation and when conducting air tests to determine the tightness of the sheathing. Breather plugs are kept out when conducting air tests of structural boundaries and at all other times in order to permit the migration of moisture from the fibrous glass insulation.

635-2.25 REFRIGERATED SPACE DOORS. Refrigerator doors used on new construction or replacement of damaged doors may be either of two types.

635-2.26 Type A. Commercial, lightweight, single seal type with front and back panels consisting of 3/8 inch (minimum) exterior grade plywood with a facing of 26-gage (minimum) stainless steel type 302 No. 4 finish all bonded together and to the insulation. Edge perimeter may consist of either 3/4 inch exterior grade plywood with an overlay of extruded neoprene, all bonded together and to the insulation or 20-gage stainless steel sheathing, type 302, No. 4 finish all welded. The neoprene extrusion forms the door overlap to which the air seal gasket is to be secured. The frame component consists of a 3/4 inch (minimum) exterior grade plywood jamb and a 1-5/8 inch Douglas fir face causing, both with an overlay of extruded neoprene or sheathed with 20-gage stainless steel, as above. All welded joints are ground smooth and polished.

635-2.27 Type B. Commercial, lightweight, single seal type with sheathing, front and back panels including perimeter edges and frame, consisting of reinforced fiberglass polyester laminate of fire-resistant resin per MIL-B-21607. One-eighth inch minimum thickness, permanently bonded into a single unit with the above resin or a suitable epoxy smooth. The color should be white either integrally pigmented or by installation of a molded white gel coat a minimum of 0.01 inches thick. Except for the gasketed edge, the corners and edges are rounded. Clearances between the door and frame should not exceed 1/2 inch. Insulation is polyurethane foam, MIL-I-24172, nominal density of 2 pounds per cubic foot.

635-2.28 The doors are factory assembled and aligned complete with frames, hinges, hardware, gasket, and thermal breaks, so that they may be secured aboard ship in steel or joiner bulkheads without distortion of the plane of the frames or disturbing the gasket seals. The door is operable from both sides. A padlocking device with a suitable inside emergency release having a non-metallic push rod is provided for each door. A label plate or other suitable device containing directions for operating the emergency lock release is permanently mounted on the door over the emergency lock release. Each door is provided with a hold-open, self-falling hook latch with a rubber bumper. Each door will be provided with two or three hinges depending on door size and weight. All hardware shall be either galvanized or chrome plated.

635-2.29 MAINTENANCE AND INSPECTION

635-2.30 MAINTENANCE, TESTS, CHECKS, AND INSPECTION. At all activities where PMS is installed, scheduled maintenance shall be conducted in accordance with the MRC set.

1. Sheathing shall be inspected annually to ascertain that the sheathing has not been punctured. Where sheathing had been originally installed watertight, punctures or openings in seams could allow moisture water to enter the insulation. Punctures in any type of sheathing should be repaired to prevent water egress into the insulation and for sanitary reasons to prevent collection of foreign matter.

2. If the design temperature of the space cannot be maintained, insulation should be checked as a possible source of trouble due to becoming water soaked.

3. Some spaces with fibrous insulation have pipe plugs inserted in the deck under the insulation. Removal of this plug is one way to determine if water is accumulating in the insulation space due to sheathing failure. Where spaces do not have inspection plugs, it is necessary to drill a hole in the deck to inspect as above. The hole should be tapped and fitted with a one-inch pipe plug after inspection.

4. The existence of condensation or frost formation on the exterior of refrigeration spaces are indications of areas of deterioration of insulation or insulation voids.

635-2.31 REPAIR. Required repairs will depend on the nature of the damage. When extensive deck repairs are indicated, the condition of the deck insulation should be ascertained by inspection. Holes, 12 to 18 inches square, are cut in the deck. Deck areas of less than 250 square feet require only one hole cut in the center; deck areas that are more spacious require additional holes cut in the corners. Hot cutting should not be used as it will damage the insulation.

1. If standing water or excessive moisture is found, leaks should be looked for and repaired. Then the insulation should be dried by blowing warm air through one or more inspection holes while venting through others. When the insulation is dry, the deck should be repaired. When repairs are made to the vertical sheathing, the bulkhead insulation is inspected to determine if the steel structure is corroded. Wet insulation is dried in a manner similar to that used for drying deck insulation.

2. If the fibrous glass or mineral wool insulation has been damaged by water and cannot be economically restored to its required efficiency, or is ineffective for other reasons, the insulation is to be repaired or replaced as follows:

a. Standing water shall be drained off and the material structure thoroughly dried prior to installation of the polyurethane foam material.

b. Polyurethane foam insulation shall be pour- or froth-foamed in place through appropriately spaced holes in the sheathing and allowed to fill the voids between the sheathing and the ships structure.

c. Although desirable, it is not necessary to remove the old insulation except where it will impair the application on the foam insulation.

d. Where the fibrous glass insulation and the sheathing are removed, precast polyurethane foam, may be used in lieu of pour- or froth-foamed-in-place polyurethane. The foam insulation shall be installed in conformance with the insulation manufacturer's instructions. Sheathing for overhead and bulkheads shall be supported by a system of furring and framing. Furring shall be used to serve as support for such items as coils, piping and lighting fixtures. Coils, unit coolers and their supports shall be made compatible with the development of refrigerated spaces, and furring as needed for their support shall be independent of linings. Battens shall be provided as protection in way of all cooling-coils and shall be supported independent of the lining; sufficient space shall be allowed for efficient circulation of air.

635-2.32 THERMAL INSULATION FOR DUCTS

635-2.33 APPLICATIONS. Ducts are insulated to reduce transfer of heat between the air carried in the system and the surroundings, and to prevent condensation of moisture on the ducts.

1. In general, supply trunks and ducts which carry unheated outside air are insulated where they pass through, or terminate in hot or normally heated spaces. This is to prevent condensation on the outside of the ducts in cold weather and chilling of normally heated spaces, and, in warm weather, further heating of the atmospheric air before reaching the space it is intended to cool. Supply trunks and ducts carrying preheated (45°F-60°F) air are insulated only where they pass through hot spaces. Supply ducts carrying reheated air (about 90°F) are insulated only to prevent loss of heat where they pass through spaces other than the space served.

2. To prevent discomfort to personnel, ducts carrying reheated air are insulated in way of berths in the space being served, if the temperature in the duct is higher than 90°F.

3. Insulation is applied on parts of air conditioning systems where the space dewpoint is more than 4 degrees F higher than the duct air dry bulb temperature.

4. Return air ducts from air conditioned spaces need only be insulated where they pass through heat producing spaces.

5. Insulation is applied on parts of exhaust ducts and trunks from heat producing spaces that

pass through spaces other than uptake' plenums to prevent overheating the spaces.

6. Ventilation heaters are insulated only when installed in the weather (to prevent heat loss), and where necessary in group berthing spaces (to prevent either overheating of the space of injury to personnel).

635-2.34 MATERIALS. Round ducts are generally insulated with 1-inch thick fibrous glass insulation felt, MIL-I-22023, type I, class 5. Rectangular ducts are generally insulated with 1-inch fibrous glass insulation board, MIL-I-742, type I.

1. When unfaced fibrous glass insulation felt is used, it is covered with fibrous glass cloth, MIL-C-20079, secured with adhesive, MIL-A-3316, class 1.

2. Vapor barrier coating, MIL-C-19993, is used on fibrous glass cloth faced insulation felt or board.

635-2.35 INSTALLATION. Insulation is installed and lagged (covered) on ducts where required, as shown on NAVSEA Drawing No. 805-1749058 and in accordance with the instructions below.

1. Ducts are insulated by applying adhesive on the underside of flat surfaces and other necessary locations. applying the insulation to the duct and tying the insulation in place with 0.049 inch diameter galvanized steel wire or fibrous glass thread, MIL-C-20079, type III, to hold the insulation in place until lagging is applied. The insulation felt is lagged with fibrous glass cloth, secured with the specified adhesive. If hard faced fibrous glass insulation board is used on the duct, the joints of the board are covered with fibrous glass tape, MIL-C-20079, secured with adhesive, MIL-A-3316, type II, class 1.

2. To apply insulation to ventilation heaters, first cut the hard faced fibrous glass board in panels to fit all surfaces except the standing flanges, beveling the edges of the panels at 45° to permit access to the bolts in the flanges. Coat the surfaces to be insulated with cement and fit the panels to the coated surfaces applying sufficient pressure to ensure adherence of the panel to the surface. All seams in the fibrous glass board panels are to be taped with 2-inch-wide fibrous glass tape, MIL-C-20079, type II class 1, applied with adhesive cement. To assist in holding the panels in place and to cover the exposed fibrous glass, the beveled boundaries of the panels are to be covered with 3-inch wide fibrous glass tape, leaving a 3/4-inch lap on the standing flange. No lagging of the type I fibrous glass board insulaton is required. Casings of cooling coils are generally insulated at the factory. Where the insulation has not been installed prior to delivery, the casings should be insulated as specified above for heaters.

3. Vapor barrier coatings are required on the finished surface, including flanges, seams, and joints of insulated air conditioning ducts and trunks and are applied as follows: Three alternate coats, white, orange, and white in that order of coating compound, MIL-C-19993, over fibrous glass cloth faced insulation board or felt.

4. After installation, the faced insulation is painted to match the other surfaces in the compartment.

5. Insulation, where required on watertight ducts, shall not be installed until specified compartment pressure tests have been completed.

635-2.36 MAINTENANCE. Where PMS is installed, scheduled maintenance shall be conducted in accordance with the MRC set.

1. The insulation and lagging of ducts should be inspected annually to ascertain if any damage has been incurred or if condensatin has saturated the insulation and lagging.

2. Damage to the insulation is particularly likely to occur on vertical trunks due to passage of personnel. Condensation may occur under extreme conditions, and insulation which has failed should be replaced.

635-2.37 REPAIR. Where bonded fibrous glass insulation or lagging has been damaged, the affected sections should be replaced, following the same procedure given above for installation.

1. Where fibrous glass board has been damaged. it should be repaired if possible, using the method described for repair of fibrous glass hull board insulation or, if that is not practicable, it should be replaced.

2. Although not directly concerned with the repair of ventilation systems, one point in connection with maintenance is of considerable importance. When insulation or paint is being removed from a compartment, all ventilation terminals drawing air from the space are to be protected with thin cloth or screen to prevent the entrance of paint and insulation dust and particles. This is necessary to prevent the creation of a fire hazard through the adherence of paint dust to the interior surfaces of ducts, fans, and heaters, in addition to reduction of the ventilation effectiveness because of clogging.

635-2.38 ACOUSTIC-ABSORPTION TREATMENT FOR COMPARTMENTS AND DUCTS

635-2.39 APPLICATIONS. Acoustic-absorption treatment of compartments and ducts is installed as necessary to meet the space noise criteria for the particular ship.

635-2.40 MATERIALS. The acoustic-absorption treatment consists of fibrous glass sound absorbing felt, MIL-I-22023, type II, sheathed with 0.04 inch thick aluminum, QQ-A-250/8, perforated with 3/16-inch diameter holes on 3/8-inch or 1/2-inch centers or perforated hard-surfaced fibrous glass acoustical absorption board conforming to MIL-A-23054, except that the absorption board is not installed in areas where it is subject to damage by movement of equipment or personnel.

635-2.41 INSTALLATION OF ACOUSTIC-ABSORPTION TREATMENT. The acoustic-absorption treatment is normally installed in compartments and ducts, where required, in accordance with procedures contained herein.

1. Acoustic-absorption treatment for ducts consists of:

a. One-inch thick fibrous-glass sound-absorbing felt installed internally in the duct is generally used in the treatment of ducts. Two-inch thickness is used where greater absorption is required. Perforated-aluminum sheathing forming the inside surface of duct is secured over the face of the felt to protect it and to provide a smooth surface in accordance with NAVSEA Drawing No. S3901-921905.

b. For ventilation or air conditioning systems requiring high noise attenuation with limited ductwork, prefabricated commercial sound absorbers have been approved on a case basis. These units have been used where the desired noise attenuation was obtained with a resultant weight or cost reduction.

2. Acoustic-absorption treatment for compartments consists of:

a. Two-inch thick fibrous-glass sound-absorbing felt sheathed with perforated aluminum installed in accordance with NAVSEA Drawing No. S3901-921905, sheet 2, and 805-1749058 with an air space between the felt and the overhead of the space. or

b. Two-inch thick acoustic-absorption board, installed without an air space and with its joints taped as shown on NAVSEA Drawing No. 805-2483105.

3. Acoustic-absorption treatment is installed on the plane surfaces only of boundaries requiring treatment. If treatment is required for any boundary which also requires thermal insulation, the acoustic-absorption treatment is applied on the plane surfaces and thermal-insulation board on the beams and stiffeners.

4. Acoustic treatment is installed on the overhead and boundary bulkheads as required to meet the noise level limitations imposed by the ships specifications. In general, treatment is installed on the overhead in the pilot house, chartroom, and wardroom, and on the overhead and bulkheads in the CIC, sonar control room, radio room, crypto room, IC room, and fan rooms.

5. Where acoustic treatment is installed in compartments on surface ships, the doors shall not be treated unless the additional area is necessary to obtain the desired noise reduction.

6. Acoustic treatment is not generally required behind large equipment or status boards which hide the bulkheads.

7. When acoustic insulation and damping treatment are both required, the damping is installed first. The studs, attached to the bulkhead, pass through the damping tile. Studs shall not be attached directly to the damping.

8. Acoustical absorption treated telephone booths are generally wall type booths, constructed without doors, but closed on top, back, and sides. The booths are constructed in accordance with NAVSEA Drawing No. 805-1632788. Painting of acoustical absorption treatment is to be avoided to the maximum practicable extent since plugging the holes in the perforated sheathing or facing with paint can change the sound absorbing properties of the treatment. However, where painting is required for appearance or, as in CIC, for functional reasons, the paint is sprayed or brushed on in thin coats, taking care not to plug or bridge the holes in the sheathing or facing.

635-2.42 INSPECTION. All acoustical treatments should be inspected annually to ascertain if any damage has been incurred. Action should be taken to have all damage, including that considered as minor, repaired at once, since the effectiveness of many acoustical treatments depend upon the maintenance of their integrity.

635-2.38 ACOUSTIC-ABSORPTION TREATMENT FOR COMPARTMENTS AND DUCTS

635-2.39 APPLICATIONS. Acoustic-absorption treatment of compartments and ducts is installed as necessary to meet the space noise criteria for the particular ship.

635-2.40 MATERIALS. The acoustic-absorption treatment consists of fibrous glass sound absorbing felt, MIL-I-22023, type II, sheathed with 0.04 inch thick aluminum, QQ-A-250/8, perforated with 3/16-inch diameter holes on 3/8-inch or 1/2-inch centers or perforated hard-surfaced fibrous glass acoustical absorption board conforming to MIL-A-23054, except that the absorption board is not installed in areas where it is subject to damage by movement of equipment or personnel.

635-2.41 INSTALLATION OF ACOUSTIC-ABSORPTION TREATMENT. The acoustic-absorption treatment is normally installed in compartments and ducts, where required, in accordance with procedures contained herein.

1. Acoustic-absorption treatment for ducts consists of:

a. One-inch thick fibrous-glass sound-absorbing felt installed internally in the duct is generally used in the treatment of ducts. Two-inch thickness is used where greater absorption is required. Perforated-aluminum sheathing forming the inside surface of duct is secured over the face of the felt to protect it and to provide a smooth surface in accordance with NAVSEA Drawing No. S3901-921905.

b. For ventilation or air conditioning systems requiring high noise attenuation with limited ductwork, prefabricated commercial sound absorbers have been approved on a case basis. These units have been used where the desired noise attenuation was obtained with a resultant weight or cost reduction.

2. Acoustic-absorption treatment for compartments consists of:

a. Two-inch thick fibrous-glass sound-absorbing felt sheathed with perforated aluminum installed in accordance with NAVSEA Drawing No. S3901-921905, sheet 2, and 805-1749058 with an air space between the felt and the overhead of the space, or

b. Two-inch thick acoustic-absorption board, installed without an air space and with its joints taped as shown on NAVSEA Drawing No. 805-2483105.

3. Acoustic-absorption treatment is installed on the plane surfaces only of boundaries requiring treatment. If treatment is required for any boundary which also requires thermal insulation, the acoustic-absorption treatment is applied on the plane surfaces and thermal-insulation board on the beams and stiffeners.

4. Acoustic treatment is installed on the overhead and boundary bulkheads as required to meet the noise level limitations imposed by the ships specifications. In general, treatment is installed on the overhead in the pilot house, chartroom, and wardroom, and on the overhead and bulkheads in the CIC, sonar control room, radio room, crypto room, IC room, and fan rooms.

5. Where acoustic treatment is installed in compartments on surface ships, the doors shall not be treated unless the additional area is necessary to obtain the desired noise reduction.

6. Acoustic treatment is not generally required behind large equipment or status boards which hide the bulkheads.

7. When acoustic insulation and damping treatment are both required, the damping is installed first. The studs, attached to the bulkhead, pass through the damping tile. Studs shall not be attached directly to the damping.

8. Acoustical absorption treated telephone booths are generally wall type booths, constructed without doors, but closed on top, back, and sides. The booths are constructed in accordance with NAVSEA Drawing No. 805-1632788. Painting of acoustical absorption treatment is to be avoided to the maximum practicable extent since plugging the holes in the perforated sheathing or facing with paint can change the sound absorbing properties of the treatment. However, where painting is required for appearance or, as in CIC, for functional reasons, the paint is sprayed or brushed on in thin coats, taking care not to plug or bridge the holes in the sheathing or facing.

635-2.42 INSPECTION. All acoustical treatments should be inspected annually to ascertain if any damage has been incurred. Action should be taken to have all damage, including that considered as minor, repaired at once, since the effectiveness of many acoustical treatments depend upon the maintenance of their integrity.

APPENDIX A. SAFETY REQUIREMENTS FOR INSULATION WORKERS

635-A.1 PERMISSIBLE EXPOSURE LIMITS

1. Monitoring method. The maximum Time Weighted Average (TWA) airborne concentration of asbestos fibers to which personnel may be exposed over a specified time interval shall be as specified in paragraphs 2 and 3 herein. The monitoring and measuring method used shall be as set forth in paragraph 635-A.3

2. Eight-hour exposure limit. Effective 1 July 1976, the TWA airborne concentration of asbestos fibers to which personnel may be exposed over an eight-hour interval, shall not exceed two fibers, longer than five micrometers, per cubic centimeter of air. Prior to 1 July 1976, during implementation of controls and acquisition of necessary protective equipment, the maximum exposure concentration shall be five fibers longer than five micrometers, per cubic centimeter of air.

3. Ceiling limit. Personnel shall not be exposed to airborne concentrations of asbestos in excess of 10 fibers longer than five micrometers, per cubic centimeter of air.

635-A.2 CONTROL MEASURES

1. Industrial hygiene. Control measures are prescribed as follows:

a. Permanent and temporary local exhaust ventilation control measures shall be provided equipped with a bag filter to control asbestos dust emissions within the limits stated above. (American National Standards Institute (ANSI) Z9.2-1971 applies.)

b. Asbestos emission from asbestos fabrication, installation, or removal operations shall be prevented by the collection in bag filters of woven cotton fabrics having air flow permeabilities not exceeding 30 cubic feet per minute per square foot for felted fabrics. Each square yard of felted fabric will weigh at least 14 ounces and be at least one-sixteenth inch thick throughout. No by-pass devices are permitted. Provisions shall be made to empty the collection hoppers without creating visible emissions of particulate matters.

c. All hand-operated and power-operated tools which may produce or release asbestos fibers in excess of the permissible exposure concentrations shall be provided with local exhaust ventilation systems.

d. As practicable, asbestos shall be handled, mixed, applied, removed, cut, scored, or otherwise worked in a wet state sufficient to prevent the emission of airborne fibers in excess of the permissible exposure concentrations.

e. Asbestos-free substitute materials shall be tested, under the technical management of NAVSEC, and, if acceptable to NAVSEA, shall be used in place of asbestos containing materials.

f. No asbestos cement, mortar, coating, grout, plaster, or similar material containing asbestos shall be removed from bags, cartons, or other containers in which they are shipped, without being either wetted, or enclosed, or ventilated so as to prevent the release or airborne asbestos fibers in excess of the permissible exposure concentration.

g. Personnel engaged in the spraying of asbestos, the removal (rip-out), or demolition of pipes, structures, or equipment covered or insulated with asbestos, and in the removal or demolition of asbestos insulation or coverings shall be provided with a type C continuous flow or pressure-demand, supplied air respirator and special clothing in accordance with paragraph 2. herein.

h. All external surfaces in places of employment shall be maintained free of accumulations of asbestos fibers to prevent subsequent dispersion.

i. Asbestos waste, scrap, debris, bags, containers, equipment, and asbestos-contaminated clothing consigned for disposal, which may produce in any reasonably foreseeable use, handling, storage, processing, disposal, or transportation, airborne concentrations of asbestos fibers in excess of the permissible exposure concentration shall be collected and disposed of in sealed impermeable bags, or other closed, impermeable containers. Prior to placing in bags, asbestos wastes shall be wet down to reduce airborne concentrations. It is essential that the waste asbestos material, in bags or containers, be disposed of by burial under at least two feet of earth at a suitable sanitary land fill.

2. Personal protective equipment. Controls are prescribed as follows for use of personal protective equipment:

a. Compliance with permissible exposure limits shall not be achieved by the use of respirators except:

(1) During the time period necessary to commence industrial hygiene control measures.

(2) In work situations in which the control methods prescribed in paragraph 1 are either technically not feasible or feasible to an extent insufficient to reduce the airborne concentrations of asbestos fibers below the acceptable limit.

(3) During emergencies.

b. A respirator program shall be established as described herein. During repair of insulation or other work requiring asbestos removal,

personnel shall be protected by personnel protective equipment that provides full protection of nose, mouth, and respiratory system. This requirement shall be met by use of one of the following or their equivalent: National Institute of Occupational Safety and Health (NIOSH), Department of Health, Education, and Welfare, or Bureau of Mines, Department of the Interior approved air or self-contained respirator:

(1) Air supplying respirator (airline), type A, class II

(2) Airline masks as specified in chapter 079 (9880, section II)

(3) Oxygen breathing apparatus (OBA) as specified in chapter 079 (9880, section II)

c. A person shall not be assigned to tasks requiring the use of respirators if, based upon his most recent examination, an examining physician determines that the person will be unable to function normally wearing a respirator, or that the safety or health of the person or other personnel will be impaired by his use of a respirator.

d. Asbestos and fibrous glass handlers disposable coveralls and clothing in accordance with MIL-C-29133 (Navy) providing whole body, head, hand, and foot coverings for use by personnel exposed to airborne concentrates of asbestos fibers shall be provided. Cloth hoods, such as painters hoods, shall be worn for head covering. Disposable plastic gloves shall be worn to protect hands. Cloth gloves may be worn inside the plastic gloves for comfort, but shall not be used alone. Sleeves shall be made secure at the wrist by use of flaps provided or by use of masking tape. Stock numbers for coveralls by size are:

X-Small	NSN 8415-00-601-0792
Small	NSN 8415-00-601-0793
Medium	NSN 8415-00-601-0794
Large	NSN 8415-00-601-0797
X-Large	NSN 8415-00-601-0801
XX-Large	NSN 8415-00-601-0802

e. At any fixed place of employment, change rooms shall be provided when exposure to the airborne concentration of asbestos fibers is in excess of the permissable exposure limit.

(1) Two separate lockers or containers for each person so separated or isolated to prevent contamination of street clothes or work clothes, shall be provided. Asbestos contaminated clothing shall be transported in sealed impermeable bags or containers.

f. When ships are at an industrial site, contemplated ship force asbestos work must be planned and coordinated with the responsible officials and Industrial Hygienists of that activity so that both industrial workers and ship force are in compliance with the requirements of this Appendix and Appendix B. Violation of these requirements may involve regulatory agencies other than the Navy, and/or environmental pay differentials (bonuses) to industrial workers.

g. When ships are in port at commercial facilities (both Occupational Safety and Health Administration (OSHA) and Environmental Protection Agency (EPA) inspectors have cognizance over commercial facilities), the services of an Industrial Hygienist is recommended before undertaking asbestos work.

h. Decks and spaces in areas that become contaminated by asbestos insulation scrap and debris shall not be dry swept. These areas must be wet down by a fine spray prior to sweeping. Industrial type vacuum cleaners may be used in cleanup of the wet asbestos.

635-A.3 ENVIRONMENTAL MONITORING. Samples shall be taken and measured under the supervision of an Industrial Hygienist (see Appendix C).

1. Method of measurement. All determinations of airborne concentrations of asbestos fibers shall be made by the membrane filter method at 400-450 magnification, using phase contrast illumination, with sample mounted in high viscosity solution of membrane filter material.

2. Monitoring. Sampling shall be of such frequency and pattern to represent with reasonable accuracy the level of exposure. Sampling shall not be at intervals greater than six months. Samples shall be collected from within the breathing zone of personnel, on membrane filters of 0.8 micrometer porosity mounted in an open-face filter holder. Samples shall be taken for the determination of the 8-hour time-weighted average airborne concentrations and of the ceiling concentrations of asbestos fibers. Records of environmental monitoring shall be maintained.

NOTE: Details of techniques and requirements of the foregoing are provided through contact with activities delineated in Appendix C. Appendix D contains an explanation of the method of measurement and monitoring techniques.

635-A.4 CAUTION SIGNS AND LABELS. Caution signs shall be provided and displayed at each location where airborne concentrations of asbestos fibers may exceed the permissible exposure concentration. Signs shall be posted at such a distance from such a location so that personnel may read the signs and take necessary steps before entering the area marked by the signs. Appendix E contains examples

of caution signs and caution labels which may be made or which are commercially available.

635-A.5 MEDICAL REQUIREMENTS

1. Naval personnel in an occupation exposed to airborne concentrations of asbestos fibers shall receive, within 30 calendar days following first employment, a comprehensive medical examination, which shall include as a minimum, a chest roentgenogram (posterior-anterior 14 by 17 inches), a history to elicit symptomatology of respiratory disease, and pulmonary function tests to include forced vital capacity (FVC) and forced expiratory volume at 1 second (FEV 1.0). The same medical examination shall be conducted within 30 calendar days before or after the termination of employment.

2. Naval personnel in an occupation exposed to airborne concentrations of asbestos fibers shall receive an annual examination to include, as a minimum, a chest roentgenogram (posterior-anterior 14 by 17 inches), a history to elicit symptomatology of respiratory disease, and pulmonary function tests to include forced vital capacity (FVC) and forced expiratory volume at 1 second (FEV 1.0). X-ray films of asbestos workers shall be specially identfied to the consulting radiologist. All medical record jackets shall be marked asbestos worker.

APPENDIX B. NATIONAL EMISSION STANDARD FOR ASBESTOS

635-B.1 GENERAL

635-B.2 Care shall be taken to assure that measures to meet emission standards are compatible with occupational health and safety standards and requirements contained in Appendix A.

635-B.3 APPLICATION OF NATIONAL EMISSION STANDARDS

1. The National Emission Standards for Asbestos prohibit visible emissions.

2. The standard became effective immediately upon publication and principally applies to the discharge of asbestos fibers to the ambient atmosphere.

APPENDIX C. TECHNICAL ASSISTANCE FOR ASBESTOS CONTROL

635-C.1 SPECIFIC ASSISTANCE AVAILABLE

1. Industrial hygiene personnel at BUMED activities are available to provide consultation and technical assistance to commands in matters of occupational health.

2. Specific assistance is available in the following areas related to asbestos control:

a. Evaluation of existing controls and recommendations for improved engineering controls, e.g., local exhaust ventilation systems.

b. Analysis of personnel exposure samples where either quantity of samples or time frame for accomplishment of analysis is beyond shipyard capacity.

c. Selection of protective clothing and appropriate respiratory protective devices.

d. Monitoring personnel exposure levels through collection of air samples and performing asbestos fiber determinations.

635-C.2 FORCES AFLOAT

1. Forces afloat requiring the services of an industrial hygienist should request assistance from the nearest Navy Environmental and Preventive Medicine Unit (NAVENPVNTMEDU). The location of the units and their autovon numbers are given in table 635-C.1.

2. Ships in port may request industrial hygiene services from the Naval Regional Medical Center or clinic serving that geographic area.

3. Shore activities. Activities and departments located ashore should request industrial hygiene services from the appropriate Naval Regional Medical Center which will provide, or arrange for, the required services. Industrial hygiene services are available in the naval regions as depicted in table 635-C.2.

TABLE 635-C.1

TECHNICAL ASSISTANCE FOR FORCES AFLOAT

NAVENPVNTMEDU-2	Norfolk, VA	(Aut) 690-7671
NAVENPVNTMEDU-5	San Diego, CA	(Aut) 958-1263
NAVENPVNTMEDU-6	Pearl Harbor, HI	(Aut) 430-5131
NAVENPVNTMEDU-7	Naples, Italy	(Aut) 625-1100 Ext. 468/469

TABLE 635-C.2

TECHNICAL ASSISTANCE DIRECTORY

NAVREGMEDCEN	Industrial Hygiene Services Commercial Telephone Number
Bethesda, Maryland	(301) 295-1249
Bremerton, Washington	(206) 478-2729
Camp Lejeune, North Carolina	(919) 451-1110, ext. 4554
Camp Pendleton, California	(714) 725-3509
Charleston, South Carolina	(803) 743-6100
Corpus Christi, Texas	(512) 939-3682
Jacksonville, Florida	(904) 772-2841
Long Beach, California	(213) 547-7972
New London, Connecticut	(203) 449-4613
Newport, Rhode Island	
NAVREGMEDCLIN-Portsmouth, New Hampshire	(207) 439-1000, ext. 398
	(207) 439-1000, ext. 398
Pearl Harbor, Hawaii	(808) 433-1137
Pensacola, Florida	(904) 452-3639
Philadelphia, Pennsylvania	(215) 755-4751
Portsmouth, Virginia	(804) 393-3280
San Diego, California	(714) 225-3506

Other shore activities shall request industrial hygiene assistance from the nearest NAVENPVNTMEDU or the Navy Enviromental Health Center, 3333 Vine Street, Cincinnati, Ohio, Autovon: 989-3863 or Commercial: (513) 684-3947.

APPENDIX D. SAMPLING AND MONITORING PROCEDURES

635-D.1 PRINCIPLES OF SAMPLING

635-D.2 A dust sampling procedure must be designed so that samples of actual dust concentrations are collected accurately and consistently. The results of the analysis of these samples will reflect, realistically, the concentrations of dust at the time and place of sampling. In order to collect a sample, representative of airborne dust which is likely to enter a subject's respiratory system, it is necessary to position a collection apparatus near the nose and mouth of the subject, or in his breathing zone.

635-D.3 The concentration of dust in the air to which a worker is exposed will vary, depending upon the nature of the operation and upon the type of work performed by the operator and the position of the operator relative to the source of the dust. The amount of dust inhaled by a worker can vary daily, seasonally, and with the weather. In order to obtain representative samples of workers exposure, it is necessary to collect samples under varying conditions of weather, on different days, and at different times during a shift. The percentage of working time spent on different tasks will affect the concentration of dust the worker inhales since the different tasks usually result in exposure to different concentrations. The percentage can be determined from work schedules and by observation of work routines.

635-D.4 The daily average weighted exposure can be determined by using the following formula:

$$\frac{(\text{Hours X Conc. Task A}) + (\text{Hours X Conc. Task B}) + \text{etc.}}{8 \text{ Hours (or actual hours worked)}}$$

635-D.5 The concentration of any air contaminant resulting from an industrial operation also varies with time. Therefore, a longer sampling time will better approximate the actual average. With the recommended sampling procedure, it is possible to collect samples at the workers breathing zones for periods from 4 to 8 hours, thus permitting the evaluation of average exposures for a half or full 8-hour shift; a desirable and recommended procedure. Furthermore, dust exposures of a more normal work pattern result from the use of personal samplers. In evaluating daily exposures, samples should be collected as near as possible to workers breathing zones.

635-D-6. COLLECTING SAMPLES. The method for taking samples and counting fibers is based on a modification of the membrane filter method. The sample should be collected on a 37-mm Millipore type AA (or equivalent 0.8 micrometer porosity) filter mounted in an open-face filter holder. The holder should be fastened to the workers lapel and air drawn through the filter by means of a battery-powered personal sampler pump. The filters are contained in plastic filter holders and are supported on pads which also aid in controlling the distribution of air through the filter. To yield a more uniform sample deposit, the filter-holder face-caps should be removed. Sampling flow rates from 1.0 liter per minute (1pm) up to the maximum flow rate of personal sampler pump (usually not over 2.5 1pm) and sampling time from 15 minutes to 8 hours are acceptable provided the following restraints are considered:

1. In order to obtain an accurate estimate of the number of fibers, the statistical error resulting from the random distribution of the fibers must be kept to an acceptably low level. Since fiber counts follow a Poisson distribution, a count of 100 fibers in a sample would have a standard deviation of $\sqrt{100}$ or 10 fibers or ±10%. Thus, the 95% confidence limits would be approximately 2 standard deviations or ±20%. Since the 37-mm filter has an effective collecting area of 855 mm^2, and the projected field area of the Porton reticle is 0.005 mm^2, each field represents 1/171000 of the sample. Based on this ratio the following number of fields must be counted to measure the various limits in various sampling times:

Sampling Time (min)	Flow Rate (1pm)	Number of Fields for 100 Fibers (fibers/ml)		
		0.2	2.0	10
10	2	4350	435	91
15	2	2860	286	58*
30	2	1430	143	29*
90	1	1000	100	20
90	2	500	50*	10
240	1	260	26*	7*
240	2	180	18*	4
480	1	180	18*	4

2. Do not count a field containing over 20 bers because in addition to the fibers being counte there are also present a number of grains, which i terfere with the accuracy of the count.

3. Based on these restraints (i.e., number fields to be counted and maximum number of fib per field) acceptable sampling parameters for t various limits are marked with an asterisk above.

4. The following conclusions may be dra from this analysis:

a. The short-term limit should be for

period of at least 15 minutes and preferably 30 minutes.

b. The 2.0 fiber/cc limit may be evaluated over periods of from 90 to 480 minutes.

635-D.7 As many fields as required to yeild at least 100 fibers should be counted. In general the minimum number of fields should be 20 and the maximum 100.

635-D.8 MOUNTING SAMPLE. The mounting medium used in this method is prepared by dissolving 0.05 gram of membrane filter per ml of 1:1 solution of dimethyl phthalate and diethyl oxalate. The index of refraction of the medium thus prepared is ND = 1.47.

635-D.9 To prepare a sample for microscopic examination, a drop of the mounting medium is placed on a freshly cleaned, standard (25 X 75 mm), microscopic slide. A wedge-shaped piece with arc length of about 1 cm is excised from the filter with a scalpel and forceps and placed dust-side-up on the drop of mounting solution. A No. 1-1/2 coverslip, carefully cleaned with lens tissue, is placed over the filter wedge. Slight pressure on the coverslip achieves contact between it and the mounting medium. The sample may be examined as soon as the mount is transparent. The optical homogeneity of the resulting mount is nearly perfect, with only a slight background granularity under phase contrast, which disappears within one day. The sample should be counted within two days after mounting.

635-D.10 EVALUATION. The mounted filter samples are evaluated in terms of the concentration of asbestos fibers greater than 5 micrometers in length. A microscope equipped with phase-contrast optics and a 4-mm high-dry achromatic objective is suitable for this determination. 10X eyepieces, one of which contains a Porton or other suitable reticle at the level of the field-limiting diaphragm, should be used. The left half of the Porton reticle field serves to define the counting area of the field. Twenty fields located at random on the sample are counted and total asbestos fibers longer than 5 micrometers are recorded. Any particle having an aspect ratio of three or greater is considered a fiber.

1. The following formulae are used to determine the number of fibers/ml:

$$\frac{\text{Filter area } (mm^2)}{\text{Field area } (mm^2)} = K$$

$$\frac{\text{Average net count} \times K}{\text{Air volume samples (ml)}} = \text{fibers/ml}$$

2. For example, assume the following:

a. Area of the filter used was 855 mm^2.

b. Counting area of one field under the Porton reticle was 0.005 mm^2.

c. Average net count per field of 20 fields was 10 fibers.

d. Sample was collected at 2 liters per minute for 90 minutes.

Then

$$\frac{855\ mm^2}{0.005\ mm^2} = 171{,}000\ (K)$$

$$\frac{10 \text{ fibers} \times 171{,}000}{2{,}000 \text{ ml/min} \times 90 \text{ min}} = 9.5 \text{ fibers/ml}$$

635-D.11 CALIBRATION OF PERSONAL SAMPLER

635-D.12 The accuracy of an analysis can be no greater than the accuracy of the volume of air which is measured. Therefore, the accurate calibration of a sampling device is essential to the correct interpretation of an instruments indication. The frequency of calibration is somewhat dependent on the use, care, and handling to which the pump is subjected. Pumps should be calibrated if they have been subjected to misuse or if they have just been repaired or received from a manufacturer. If hard usage is given the instrument, more frequent calibration may be necessary.

635-D.13 Ordinarily, pumps should be calibrated in the laboratory both before they are used in the field and after they have been used to collect a large number of field samples. The accuracy of calibration is dependent on the type of instrument used as a reference. The choice of calibration instrument will depend largely upon where the calibration is to be performed. For laboratory testing, a 1-liter burette or wet-test meter should be used. In the field, a rotameter is the most convenient instrument used. The actual set-up will be the same for all of these instruments. The calibration instrument will be connected in sequence to the filter unit which will be followed by the personal sampler pump. In this way, the calibration instrument will be at atmospheric pressure. Connections between units can be made using the same type of tubing used in the personal sampling unit. ~~Each pump must be calibrated separately for each type of filter used, if, for example, it has been decided to use a filter with a different pore size.~~ The burette should be set up so that the flow is toward the narrow end of the unit.

635-D.14 Care must be exercised in the assembly procedure to insure adequate seals at the joints and

that the length of connecting tubing be kept at a minimum. Calibration should be done under the same conditions of pressure, temperature, and density as will be encountered. The rotameter should be used only in the field as a check if the diaphragm or piston pumps are not equipped with pulsation dampeners. The pulsating flow resulting from these type pumps causes the rotameter to give results which are not as accurate as that obtained with a burette or wet-test meter. Calibration can be accomplished with any of the other standard calibrating instruments, such as spirometer, Marriott's bottle, or dry-gas meter. The burette and wet-test meter were selected because of their accuracy, availability, and ease of operation.

APPENDIX E. ASBESTOS CAUTION SIGN AND LABEL SPECIFICATION

635-E.1 SIGN SPECIFICATIONS

635-E.2 Warning signs shall conform to the requirements of 20" x 14"vertical format. The signs shall display the following legend in the lower panel, with letter sizes and styles specified. Spacing between lines shall be at least equal to the height of the upper of any two lines.

LEGEND	NOTATION
Asbestos	1" Sans Serif, Gothic, or Block
Dust Hazard	3/4" Sans Serif, Gothic or Block
Avoid Breathing Dust	1/4" Gothic
Wear Assigned Protective Equipment	1/4" Gothic
Do Not Remain In Area Unless Your Work Requires It	1/4" Gothic
Breathing Asbestos Dust May Be Hazardous To Your Health	14 point Gothic

635-E.3 CAUTION LABELS

635-E.4 Caution labels shall be affixed to all raw materials, mixtures, scrap, waste, debris, and other products containing asbestos fibers, or to their containers, except that no label is required where asbestos fibers have been modified by a bonding agent, coating, binder, or other material so that during any reasonably foreseeable use, handling, storage, disposal, processing, or transportation, no airborne concentrations of asbestos fibers in excess of the exposure limits prescribed in Appendix A will be released.

635-E.5 The caution labels shall be printed in letters of sufficient size and contrast as to be readily visible and legible. The label shall state:

CAUTION

Contains Asbestos Fibers

Avoid Creating Dust

Breathing Asbestos Dust May Cause

Serious Bodily Harm